THE
# PRACTICAL MAGAZINE

No. 18. Vol. 3, 1874.

JOHN LAIRD, ESQ., M.P., OF BIRKENHEAD.

## MR. JOHN LAIRD, M.P., AND THE SHIPBUILDING TRADE OF THE MERSEY.

NO branch of British industry has made more remarkable progress than iron shipbuilding during the last twenty years. The total tonnage of vessels built in the United Kingdom in 1850, was only 133,695, and of this aggregate 120,895 tons were timber, while only 12,800 tons were iron. Ten years later, the aggregate tonnage launched in the United Kingdom was 211,968, of which 147,269 tons were wood, and 64,699 tons were iron. Eight years later still, and the aggregate annual tonnage had reached the colossal figure of 369,573 tons, 208,101 being of iron, and 161,472 being of wood. The substitution of iron for timber as a shipbuilding material has thus been mainly accomplished within the last ten or twelve years. It is estimated that the total tonnage of iron and timber vessels launched in the United Kingdom during last year is over half a million tons, being an increase within little more than twenty years of about 400 per cent. In this extraordinary progress, the port of Liverpool and its magnificent highway—the Mersey—have not participated to the same extent as the more northern rivers. Without absolute retrogression, the shipbuilding trade of the Mersey, relatively to that of other rivers, has been at a standstill during the period under review. The cause of this effect is not far to seek. Notwithstanding the splendid facilities provided by the Mersey for the prosecution of marine architecture, and the extraordinary impetus which the enormous ship-owning interest of Liverpool might be supposed to give to an industry with which it is so nearly allied, the Liverpool shipbuilders are too remote from the sources of the raw material to compete on favourable terms with the more northern rivers. The Mersey shipbuilders are under the necessity of bringing their coal and iron a long distance, and the heavy rates exacted for freight, eat up a large margin which would otherwise be left for profit. Nor is this all. Skilled artizans are usually paid at a highter rate in the south than in the north, and the shipwrights of the Mersey are no exception to this invariable rule. The shipbuilders on that river are thus doubly handicapped in their race with the shipbuilders of the Wear, the Tyne, the Tees, and the Clyde; and in consideration of the keen and active competition that is continually encountered from these rivers, it is perhaps more marvellous that the shipbuilders of the Mersey should have held their own so well, than that they should not have made greater progress.

At the present time there are six shipbuilding firms carrying on operations on the Mersey. These firms are:

Messrs. Laird Brothers, Birkenhead.
" Thomas Royden and Sons, Liverpool.
" R. and J. Evans, Liverpool.
" Potter and Hodgkinson, Liverpool.
" Bowdler, Chaffers and Company, Seacombe.
" Clover, Clayton and Company, Birkenhead.

Last year, the total tonnage of the steamers built by the six firms above mentioned was 33,507, and of the sailing ships 12,164 tons, making an aggregate of 45,671 tons. The proportion contributed by Messrs. Laird, Brothers, to this aggregate was over 13,000 tons. Of eleven large steamers built by this eminent firm in 1873, there were three for the Pacific Steam Navigation Company. Messrs. Bowdler, Chaffers, and Company come next, with seven steamers of 7,000 tons burthen. Messrs. Thomas Royden and Sons contribute five steamers, of 5,407 tons, including three for the African Steamship Company, and two sailing vessels, bringing their aggregate tonnage for the year up to 6,764 tons. Messrs. R. and J. Evans and Company make up a total of 7,900 tons with four steamers, and one sailing ship. Messrs. Potter and Hodgkinson have launched 5,000 tons.

Among other shipbuilders who have at different times carried on operations on the Mersey are, Mr. John Grantham (who has published a book on iron shipbuilding, and is a prominent member of the Institute of Naval Architects), Mr. Thomas Wilson, Messrs. Cato, Miller, and Company, Messrs. Thomas Vernon and Sons, Messrs. Berry, Curtis, and Kennedy, and Mr. Jordan.

There is no firm in the above list, nor indeed in the whole kingdom, that has attained to greater eminence than the Messrs. Laird, of Birkenhead. The distinguished services rendered by that firm to the science of naval architecture have been recognized over and over again not only by our Government, but by many foreign potentates. It is only proper, therefore, that the Messrs. Laird should here be acknowledged as the pioneers of the iron shipbuilding trade of the Mersey, and in placing on record something like a connected history of their career, and of the achievements which have made their names "familiar in our mouths as household words," we shall be undertaking the performance of a hitherto unattempted task.

The Birkenhead ironworks were commenced in 1824, by the late Mr. William Laird, father of the present Member for that borough. For some years previously, Mr. William Laird had taken an active interest in everything relating to the shipping trade of Liverpool; and in 1822, he was one of the originators of the St. George's Steam Packet Company, formed for the purpose of running vessels between Liverpool and Glasgow. This company, in course of time, extended its ramifications until it had vessels running from Dublin, Cork, and other ports in Ireland, to the principal ports in England; and it is one of its most interesting reminiscences that it owned the Sirius, the first steamship that crossed the Atlantic to New York.

Another leading steamship company, which the late Mr. William Laird assisted to organize, was the Dublin and Liverpool Steam Navigation Company. Commencing operations in a small way with only two vessels—the "Liffey" and the "Mersey"—for the carriage of goods between Liverpool and Dublin, this company was afterwards amalgamated with the City of Dublin Steam Packet Company, of which more anon. The latter company was incorporated by royal charter, and built several vessels in an early stage of its career, which were regarded as superior to any then employed in the coasting trade. One of these was the "Royal William," built in 1837, which made the voyage from Dublin to Liverpool, on the 9th of October of that year, in 9 hours and 48 minutes. This vessel subsequently made the voyage from Liverpool to New York, in nineteen days, and the return voyage from New York, she accomplished in 14½ days. Among the more favourite steamers built for this company, and employed on the Liverpool and Dublin station, our readers will recollect the "Duke of Cambridge," the "Duchess of Kent," the "Prince," the "Princess," the "Iron Duke," the "Windsor," the "St. Patrick," the "St. Columba," the "Eblana," and the "Trafalgar." It was this company, also, that established the well-known line of steamers employed in conveying the mails between Holyhead and Kingstown.

We now take final leave of the father, and follow the career of the son. In the year 1829, Mr. John Laird built at the Birkenhead ironworks one of the first, if not the first iron ship that was ever constructed. This was a lighter of 60 tons measurement, 60 ft. in length, 13 ft. 4 in. in breadth, and 6 ft. depth of hold. She was built to the order of the Irish Inland Company, for the navigation of the Irish lakes and canals; and it is noteworthy that, although much difficulty was experienced in obtaining men to bend and fit the plates and frames, and in procuring angle iron and plates of suitable size, this pioneer vessel was not only strongly built, but was framed and plated much in the same way that our best steamers are built at the present day. It is, however, claimed for Scotland, that in 1818 the use of iron in shipbuilding was commenced by Mr. Robert Wilson, who built the passenger-boat Vulcan for the Forth and Clyde Canal Company; so that, although Mr. John Laird was the first on the Mersey, and probably also the first in England, to make use of iron in lieu of timber, his claims to this distinction are fairly shared by others. It is undoubtedly due to Mr. Laird, however, that the superiority of iron over timber came to be so largely recognized. People were so unwilling to trust themselves to an iron hull, that on the Clyde no vessel of any size was constructed of that material until 1838, when Messrs. Tod & Macgregor, of Glasgow, built the "Royal Sovereign" and the "Royal George," for the trade between that port and Liverpool. But, after having satisfied himself, not only of the practicability of introducing iron into the shipbuilding trade, but of its superiority to timber, Mr. Laird persevered with its use in the face of many obstacles and almost unconquerable prejudice. In 1833 he built an iron paddle-wheel vessel, named the "Lady Lansdowne," for the City of Dublin Steam Packet Company. She was strongly framed and plated as a sea-going vessel, and after being sent over from Liverpool in pieces, she was put together on Loch Derg in Ireland. With a builder's measurement of 148 tons, her length was 133 ft., her breadth 17 ft., and her depth in hold 9 ft. 6 in. In the following year, Mr. Laird constructed a second paddle steamer for G. B. Lamar, Esq., of Savannah, United States, called the "John Randolph." This was the first iron vessel ever seen on American waters. She was shipped in pieces at Liverpool, and riveted together in the Savannah River, where for several years afterwards she was used as a tug-boat. A third paddle steamer was built by Mr. Laird in 1834, for the navigation of the Lower Shannon. She was built to the order of the City of Dublin Steam Packet Company, and was the largest iron vessel constructed up to that time, her burden being 300 tons. After thirty years service in Ireland, the "Garryowen" was sold for navigation on the African coast.

Mr. Laird's next important naval undertaking was the fitting out of General Chesney's expedition for the exploration of the River Euphrates. This expedition was fitted out in 1834, and to the order of the Honourable East India Company two vessels—the "Tigris" and the "Euphrates"—were built for this purpose in 1835. The latter was 179 tons, 105 ft. in length, 19 ft. in breadth, and 7 ft. 6 in. in depth in hold. The former was 109 tons, 90 ft. in length, 10 ft. in breadth, and 6 ft. 6 in. depth in hold. Both vessels, after having been put together at Mr. Laird's works, were taken to pieces again and shipped to the coast of Syria. They were carried across the desert by camels, and reconstructed on the banks of the Euphrates. Iron shipbuilders, engineers, boiler-makers, joiners, carpenters, and other artizans, had to be sent out to the Euphrates for that purpose. Such an undertaking would be a comparatively easy matter with the facilities that now exist, but forty years ago it was one both hazardous and difficult.

The success of the vessels employed in the exploration of the Euphrates induced the East India Company to purchase from Mr. Laird, for the navigation of the Indus, a steamer that he was building for Savannah. This vessel, named the "Indus," was 300 tons burthen, 115 ft. in length, 24 ft. in breadth, and 8 ft. depth in hold. She was thus, with only one exception—that of the "Chatham," built for the same Company, and 375 tons burthen—the largest iron vessel constructed up to that time. She was launched in 1837; and after being shipped in pieces to Bombay, she was put together again at that port and steamed therefrom to the Indus. In the same year Mr. Laird launched "L'Egyptien," the first iron steamer constructed for the navigation of the Nile, which steamed from Liverpool to Alexandria.

Up to 1834, Mr. Laird had constructed six iron vessels altogether, and his resolute perseverance with the use of iron for shipbuilding purposes when it was discarded and discredited by other builders, entitles him to be regarded as the pioneer of iron shipbuilding. But he had not even yet conquered all his difficulties, although he had unmistakeably proved that iron could with advantage be used in the construction of vessels of all kinds, whether for lake, river, or ocean navigation. In consequence of the success of the vessels Mr. Laird had built up to this time, and after witnessing the performances of "Lady Lansdowne" and the "Garryowen," the well-known Mr. Assheton Smith, in the spring of 1835, applied to Mr. Laird to build an iron yacht. Mr. Laird undertook to do so, and a contract was concluded for a vessel 144 ft. in length, 24 ft. in breadth, and 13 ft. in hold. But his friends persuaded Mr. Smith that in entering into such a contract he had made a ruinous mistake; that a yacht built of iron would never be safe; and the conclusion of the matter was that he asked Mr. Laird to cancel the contract. This Mr. Laird agreed to do in September, 1835; but the circumstances of the case having become known in shipping circles, the prejudice against iron vessels was strengthened and confirmed. It was well known that Mr. Smith had given the order, and it was not unreasonably concluded that something was wrong when it was cancelled, more especially as he shortly afterwards got a wooden vessel, the "Fire King," built instead. Prejudice did not, however, long hold Mr. Assheton Smith in thrall. He could not help feeling convinced that the iron vessels already built by Mr. Laird were remarkably successful; and despite, therefore, the attempted dissuasion of his friends, he again saw Mr. Laird, and in 1837 negotiated with him for the construction of an iron yacht—the "Glow-worm"—of 362 tons burthen, 150 ft. long, 22 ft. beam, and 100 horse power. After having been used as a yacht for some years, the "Glow-worm" was made to serve the more utilitarian purpose of a trading vessel between Scotland and Ireland. Her construction may be said to mark an epoch in the history of iron shipbuilding, for no one was credited with greater experience and discrimination in naval matters than Mr. Assheton Smith, and his example was sufficient to convert the unbelieving and confirm the faith of many doubters.

It is interesting to notice that the first important advance in the direction of building a larger size of iron vessels was made by Mr. Laird in 1837, when he received from the General Steam Navigation Company of London an order to build the "Rainbow," for service between London and Ramsgate. This vessel was about 600 tons burthen, 185 ft. long, 25 ft. beam, and carried engines of 180 horse-power. After being employed for some time in the London and Antwerp trade, the "Rainbow," which was the fastest vessel of her day, ran for many years as a cargo steamer between Hâvre and London, and was only broken up in 1869.

In 1838 a screw steamer, with a propeller on Ericsson's plan, was built at the Birkenhead works for river and canal work in the United Kingdom. Although only 33 tons burthen, 63 ft. 5 in. in length, 10 ft. in breadth, and 7 ft. in depth, she made a voyage from Liverpool to New York under canvas—her propeller having been taken out—with every success. Until he built this vessel, the "Robert F. Stockton," Mr. Laird had constructed only paddle steamers; and we believe we are correct in saying that, with at the utmost only two or three exceptions, she was the first screw vessel built.

The vessel already built by Mr. Laird for the East India Company had given so much satisfaction, that that body contracted with him in 1839 for the construction of an armed flotilla, to be employed in the defence of their interests in the East. Three vessels of light draught, and each carrying two 9-pounder pivot guns on swivels, were therefore built at Birkenhead for the navigation of the Tigris and the Euphrates. They were named respectively the "Nimrod," the "Nitocris," and the "Assyria." They were all of the same size and build—153 tons burthen, 103 ft. in length, 18 ft. in breadth, and 6 ft. 7¼ in. depth in hold. Like the previous vessels built for the same company, they were sent out in pieces and put together by Birkenhead artizans on the banks of the Euphrates. Shortly afterwards, on the suggestion of the late Mr. Peacock, of the Hon. East India Company, who consulted Mr. Laird as to the propriety of building a larger class of vessels, to carry 24 and 32-pounders, for service on the coast of India, the latter built the "Nemesis" and "Phlegethon," each carrying two 32-pounder pivot guns, and the "Ariadne" and the "Medusa," carrying each two 24-pounder pivot guns. These were the first vessels built to show the advantage of iron vessels of light draught, carrying a heavy armament, and possessing sea-going qualities that enabled them to make long voyages; one of the four, the "Nemesis," of 660 tons burthen, was under the command of Captain (now Admiral Sir William) Hall, R.N., and was greatly distinguished in the China wars. With the "Nemesis" and the "Phlegethon," although only vessels of 5 ft. draught, the interesting experiment of rounding the Cape was made in the voyage to India; and although difficulties were anticipated from their light draught, the use of sliding keels and a drop rudder enabled those difficulties to be successfully overcome. Although the "Ariadne" and the "Medusa" were fitted up in exactly the same way as their sister ships, it was not deemed advisable to commit them to the hazardous test of rounding the Cape, and they were therefore sent out in pieces and put together at Bombay.

Mr. Laird built his first vessel for the Admiralty in 1839. Previous to that time he had made repeated applications to the Lords of the Admiralty to try the use of iron as a substitute for timber; but the prejudices of their lordships in favour of the "wooden walls" were difficult to eradicate. At last, however, they were induced through Sir C. Wood (now Viscount Halifax), the then Secretary to the Admiralty, to order from Mr. Laird an iron vessel to be called the "Dover," for the station of that name. Launched in May, 1840, the "Dover" was only 228 tons burthen, 113 ft. in length, 21 ft. in breadth, and 9 ft. 10½ in. in depth of hold; but as a mail packet she did good service for at least thirty years. In this year, also, Mr. Laird built three gunboats, the "Soudan," the "Albert," and the "Wilberforce," for exploring the Niger, for Her Majesty's Government; and in 1842 he entered into negotiations for the construction of a still larger vessel, under rather remarkable circumstances. The Mexican Government, on the representations of Mr. Laird, had been induced to order from that gentleman a vessel of 800 tons burthen and 180 horse-power, carrying two 68-pounders on pivots at each end, and four 32-pounder broadside guns. This was the heaviest armament carried at that time by wooden vessels of the "Guadaloupe" class, and on the suggestion of Mr. Laird, the Admiralty were induced to send down one of their first-class surveyors to Birkenhead to see and report upon the "Guadaloupe" before her departure for Mexico. The report presented to the Admiralty as to the merits of the "Guadaloupe" was so satisfactory, that in 1843 the late Right Hon. Sidney Herbert (afterwards Lord Herbert of Lea), Secretary of the Admiralty, and the late Right Hon. Henry Corry, M.P., junior lord of the Admiralty, requested Mr. Laird to send in designs and an estimate for a first-class paddle-wheel man-of-war, to carry the same armament as the best class of vessels then built. The construction of the "Birkenhead," a frigate of 1,400 tons and 560 horse-power was the result of these negotiations.

About this time (1842) an accident happened to one of the iron vessels built by Mr. Laird which went far to confirm the growing confidence in the strength of iron ships. The ferry steamer "Nun" grounded on the stone pier at Birkenhead, her after-end resting on the pier and her bow on the bare rock, the distance between the points of support being 81 ft. The whole weight of machinery, 65 tons, was in the middle of this unsupported space, but she floated off next tide without having received the slightest damage.

Enough, and perhaps more than enough, has been stated to show that no one has done more to promote the use of iron as a material for shipbuilding purposes than Mr. John Laird. Before

1840 he had built altogether thirty-two iron vessels of all kinds. Every one of these vessels was in its way a pioneer. If it did not lead the way in some improvement or new phase of iron shipbuilding, it was the first vessel of its kind built for navigating some part of the world where iron ships were previously unknown. Thus the first iron vessels used in India, in China, in South America, in the United States, and in Egypt, were furnished by Mr. Laird. The unequivocal success of these vessels turned the tide completely in favour of the use of iron, and even builders who had opposed the construction of such vessels were ultimately compelled to adapt their works to the requirements of iron shipbuilding, or go to the wall altogether. One of the first and most serious drawbacks to the use of iron was the difficulty of working the compasses. At Mr. Laird's suggestion, the "Garryowen" was placed at the disposal of the Admiralty by the City of Dublin Steam Packet Company, for the purpose of making experiments with a view to overcoming this difficulty. Captain Johnson, R.N., a distinguished naval officer, was entrusted with this onerous commission. His experiments were all of a highly scientific character, and did much to make the regulation of the compasses of iron ships as easy as that of timber vessels; but the first really practical results were obtained by Professor Airey, in the course of his experiments on the "Rainbow," a vessel which, as already stated, was built by Mr. Laird for the General Steam Navigation Company. The settlement of the practical difficulty of adjusting the compasses, gave a great impetus to the construction of iron ships for seagoing; and one of its first results was the building of an iron sailing-vessel by Mr. Laird, for sea-going in the China trade.

In 1843, Mr. Laird took out a patent for vessels with a rudder at each end, adapted either for ferry or gunboats. The object of its application to the latter, is to allow of two guns being fired at each end on line of keel, without exposing the broadside to the enemy. Many vessels subsequently built on this principle were found to answer very well for foreign armaments; and it is noteworthy that the ferryboats used on the Mersey have since been built almost entirely on this plan. The two well-known ferryboats the "Prince" and the "Queen," now employed at Woodside Ferry, Birkenhead, were built by Mr. Laird in 1844. Each is 250 tons burthen, 110 ft. in length, 22 ft. in breadth, and 9 ft. 3 in. depth of hold.

Another patent taken out by Mr. Laird was for the construction of river boats of shallow draught of water. This particular class of vessel was undertaken in consequence of the great difficulty of navigating the Indus, a very tortuous river, having its bed 6,300 ft. above the level of the sea, and flowing for hundreds of miles on a ridge elevated above the plains; while for 110 miles of its course it is an enormous torrent. The first vessel built on Mr. Laird's plan for the navigation of the Indus was the "Loodhiana," of 446 tons burthen, 160 ft. length, 24 ft. breadth, and only 2 ft. draught of water. This vessel was found to answer so well, that the only boats afterwards constructed for the East India Company for the navigation of the Indus, were built on the same principle.

The exigencies of the Russian war gave a stimulus to the iron shipbuilding trade of this country, such as it had never before received and has not since experienced, if we except the subsequent American war, when light vessels came so much into request for running the blockade of the Southern ports. One of the Admiralty requirements during the Russian war was the construction of what are known as mortar vessels, having great strength and a light draught. Such a vessel Mr. Laird built in the incredibly short space of *three weeks*. She was named the "Cupid," and carried a burthen of 102 tons. This was probably the quickest and smartest thing that has ever been done in naval architecture. On her trial the "Cupid" yielded such satisfactory results that the Government decided on building 60 others of the same kind. The contracts for 15 of the number were placed with Mr. Laird, along with those for fourteen gunboats, each of 230 tons burthen. It was an occasion of emergency, and Mr. Laird was equal to the occasion. He completed the whole twenty-nine vessels in eight months from the time they were ordered, being at the rate of nearly one per week. The gunboats were all constructed of wood, while the mortar-boats were built of iron. All the fifteen mortar boats were launched in the two months of March and April, 1856, so as to be ready for the spring and summer campaign in the Baltic.

In the spring of 1860 Mr. Laird launched, for the City of Dublin Steamship Company's mail packet service between Kingstown and Holyhead, the "Ulster," "Munster," and "Connaught," three duplicate vessels of 2,039 tons; builder's measurement, 334 ft. length, 35 ft. breadth, and 19 ft. depth of hold. These vessels, which were built to Mr. Laird's own designs, have been running to the station ever since, and are still doing as good service as they did fourteen years ago. The "Connaught" attained a speed of more than 18 knots on her official trial at Stokes Bay—a rate of speed which has never yet been excelled by any sea-going ship. To the managing director of the Dublin Steam Packet Company we are indebted for the following statement of the performances of the Kingstown and Holyhead boats:—

AVERAGE TIME OF PASSAGES OF THE FOUR MAIL PACKETS BETWEEN KINGSTOWN AND HOLYHEAD (DISTANCE 56 KNOTS) FOR 13 YEARS, ENDING 30TH SEPTEMBER, 1873.

| | Connaught. | | Leinster. | | Munster. | | Ulster. | | Four Packets. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Trips. | Time. | Trips. | Time. | Trips. | Time. | Trips. | Time. | Trips. | Time. |
| Winter half-year. | 2,814 | 3.55.7 | 2,172 | 3.57.0 | 2,096 | 3.59.1 | 2,389 | 4.1.8 | 9,471 | 3.58.3 |
| Summer half-year. | 2,394 | 3.52.0 | 2,548 | 3.52,4 | 2,421 | 3.52.2 | 2,150 | 3.55.9 | 9,513 | 3.53.2 |
| Whole year. | 5,208 | 3.53.9 | 4,720 | 3.54.5 | 4,517 | 3.55.5 | 4,539 | 3.58.9 | 18,984 | 3.55.7 |

In consideration of events that have recently transpired, there is a kind of mournful interest in recording the fact that the steam launch with which the British Government furnished Dr. Livingstone in 1858, for his explorations on the Nile, was built at the Birkenhead works, while from a scientific point of view, this vessel is interesting as being the first constructed of the homogeneous steel plates, which although only half as thick, have a strength equal to that of the best iron boiler plates. "Dr. Livingstone's" launch was 75 ft. long, 8 ft. broad, and 3 ft. deep, and in form resembled a large flat-bottomed canoe, each end having a great rise like those craft, which from their handiness in turning or putting ashore, if necessary, are best adapted for shallow river navigation. The hull was divided into three sections, each complete and water-tight in itself, the centre section containing the boiler and engines, and the different parts were connected together by a plan patented by the late Mr. Macgregor Laird. The rudder was allowed to hang lower than the vessel, whose draught was so light (about 14 in.) that it could not otherwise have sufficient power in directing her course. With such a small depth of hull, sleeping berths could not possibly be provided; but each end of the vessel was covered in with awnings, so that it was something like sleeping in a tent. Seats were placed below the level of the deck like those in the stern sheets of a river barge, with bunks or slide-lockers below them for the stowage of provisions and stores. In a preliminary trial on the Mersey this launch attained a speed of 9 miles an hour, on a draught of water of about 13 in.

For the great ocean steamship companies that have their head quarters at Liverpool, Mr. Laird and his sons have built some of the finest merchantmen afloat. To the order of the Pacific Steam Navigation Company they have built the "Corcovado," the "Puno," and the "Britannia," three of the fastest vessels in the large fleet of that company. We have before us a statement of the log of the "Corcovado" on her first voyage from Liverpool to Valparaiso and Callao, and as she is a fair specimen of other vessels of her class built at Birkenhead, we may refer to the facts before us in proof of their capabilities. The "Corcovado" carried a burthen of 3,434 tons B. M., was 375 ft. in length, 43 ft. in breadth, and 33 ft. 9 in. in depth. Her ordinary load draught of water was 22 ft., and the dead weight of coal, cargo, stores, provisions, &c. carried on this draught was 2,580 tons. She had compound engines with inverted cylinders, the diameter of the high-pressure cylinders being 60 in., and of the low-pressure cylinders 103 in., length of stroke 4 ft. 6 in. The screw is 19·6 ft. diameter, and fitted with four bolted-on blades, and the engine indicated on trial about 3,000 horse-power. The engines as well as the vessel, were constructed at Birkenhead. With these explanatory notes, the log on the opposite page will be able to tell its own tale.

The following, however, is a summary of the results detailed, and it should be noted that the coal used in the return voyage was to a great extent Chili and inferior Welch coals, so that this fact, added to the foul state of the vessel's bottom, is sufficient to account for the larger consumption and lower speed.

| | Outwards. | Homewards. |
|---|---|---|
| Total time occupied on voyage | 52 days 20½ hrs. | 52 days 14¼ hrs. |
| Actual steaming time | 33 „ 13½ „ | 38 „ 8¼ „ |
| Distance run | 10,906 knots. | 11,022 knots. |
| Mean speed per hour | 13·54 „ | 11·98 „ |
| Total consumption of coal, including winches, galleys, condensers, keeping steam in ports, &c. | 2085 tons. | 2485 tons. |

| | Outwards. | Homewards. |
|---|---|---|
| Actual consumption at sea | 1916 tons | 2305 tons |
| Average consumption per day | 57 „ | 60 „ |
| Number of knots per ton of coal | 5·69 knots. | 4·76 knots. |
| Mean draft of water on voyage | 21 ft. 0 in. | 21 ft. 0 in. |
| Dead weight on board. | 2230 tons. | 2230 tons. |

In 1865, Messrs. Laird Brothers built for the National Steamship Company the "Queen" of 3,253 tons burthen, 368 ft. length, 42 ft. 3 in. breadth, and 29 ft. 5 in. depth of hold. The beautiful symmetrical lines of this vessel made her the cynosure of the shipping world at the time she was launched. She was rigged as a barque, with square sails upon her fore and main mast. Her topsails were double, and she was fully supplied with every means of working them from the deck, and so to spread or shorten sail immediately. But even with all her beauties of construction, the "Queen" was fairly eclipsed by the "Spain," another vessel launched for the same company by the Messrs. Laird, in May, 1871. The general dimensions of the "Spain" were as follow:

| | |
|---|---|
| Length between perpendiculars | 425·6 |
| Beam moulded | 43·0 |
| Depth in hold to main deck | 28·8½ |
| Height to spar deck | 7·6 |
| Tonnage—B.M. | 3931 86/94 |
| „ gross register | 4512 |
| „ net „ | 2875·9 |
| Ordinary draft at starting, about | 23·6 |
| Dead weight of coal, cargo, stores, and provisions, etc., carried on this draft | 3300 tons |

Engines—compound with inverted cylinders.
Diameter of H.P. cylinder, 60 inches.
„ L.P. cylinder, 106 inches.
Length of stroke, 54 inches.
Fitted with six double-ended circular boilers, having 24 furnaces.
The Engines indicated more than 3,000 h.p. on trial trip, and work up to about 2,800 h.p. at sea.

Between August 1871 and April 1872 the "Spain" made six voyages from Liverpool to New York and back. Several of these were made in from 27 to 28 days, including detention at New

### Outward Voyage.

Captain Nugent Sims, *Commander.*

Left Liverpool, 19th February, 1873. Time on voyage—52 days, 20 hours, 30 minutes.
Arrived at Callao, 13th April, 1873. Time at sea—33 days, 13 hours, 32 minutes.
Mean draft water on voyage, 21 feet. Mean dead weight on board, 2,230 tons.

| Port of Call. | Distance. | Actual steaming time. | Average. Pressure of steam. | Revolutions per minute. | Speed per hour. | Remarks. |
|---|---|---|---|---|---|---|
| Liverpool to | Knots. | D. H. M. | | | Knots. | |
| Bordeaux, calling at Lisbon | 635 | 1 22 45 | 58 lbs. | 50 | 13·50 | Light wind and foggy weather. |
| Corunna. | 729 | 2 8 42 | 58 „ | 48½ | 13·0 | Variable wind. |
| Rio de Janeiro | 4239 | 12 18 0 | 59 „ | 49 | 13·85 | Moderate wind and variable. |
| Monte Video | 1039 | 3 6 30 | 56 „ | 47½ | 13·20 | Moderate weather. |
| Sandy Point | 1354 | 4 6 10 | 60 „ | 48 | 13·20 | „ „ |
| Coronel | 1268 | 3 19 0 | 58 „ | 50 | 13·93 | Moderate breeze and fine weather. |
| Valparaiso, calling at | 264 | 0 19 35 | 58 „ | 51 | 13·60 | „ „ „ „ |
| Callao, one Port | 1378 | 4 8 50 | 57 „ | 48 | 13·0 | „ „ cloudy. „ |
| Total and average | 10,906 | 33 13 32 | | | 13·54 | Hull and machinery in good order. |

### Homeward Voyage.

Captain Nugent Sims, *Commander.*

Left Callao, 24th April, 1873. Time on voyage—52 days, 14 hours, 15 minutes.
Arrived in Liverpool, 16th June, 1873. Time at sea—38 days, 8 hours, 15 minutes.
Mean draft water, 21 feet. Dead weight on board, 2,230 tons.

| Port of Call. | Distance. | Actual Steaming Time. | Average. Pressure of Steam. | Revolutions per Minute. | Speed per Hour. | Remarks. |
|---|---|---|---|---|---|---|
| | Knots. | D. H. M. | | | Knots. | |
| Callao to Valparaiso, calling at three Ports on the way | 1467 | 6 1 30 | 46 lbs. | 43·6 | 10·0 | Fresh breeze and head sea. |
| Coronel | 260 | 0 21 5 | 60 „ | 50 | 12·38 | Moderate weather and fog. |
| Sandy Point | 1252 | 4 2 10 | 52 „ | 47·8 | 12·8 | Variable weather. |
| Monte Video | 1378 | 4 6 50 | 57 „ | 50·4 | 13·4 | „ „ |
| Rio de Janeiro | 1024 | 3 5 35 | 60 „ | 51 | 13·2 | Moderate breeze and fine weather. |
| St. Vincent | 2718 | 9 13 20 | 58 „ | 48 | 11·83 | Variable weather. |
| Lisbon | 1561 | 5 14 5 | 58 „ | 48 | 11·70 | Strong head winds. |
| Bordeaux | 711 | 2 9 10 | 58 „ | 48 | 12·3 | Fresh breeze. |
| Liverpool | 651 | 2 6 30 | 58 „ | 48 | 12·1 | Light variable winds. |
| | 11,022 | 38 8 15 | | | 11·98 | Hull and machinery in good order. |

York. Subjoined is an abstract of the log of her sixth voyage, the coal used being mixed Welch and American, and the consumption including that used for cooking and other ship purposes :—

OUTWARD VOYAGE—Mean draft, about . 23′ 7″
Displacement „ . 7700 tons.

HOMEWARD DO. Mean draft „ . 23′ 4″
Displacement „ . 7600 tons.

OUTWARD VOYAGE.

| Date. | Winds. | Distance. | Force of Wind. | Pressure of Steam. | Coals Consumed. | Hours under Sail. | Days out. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 1872 | | | | | per diem | Sq. Sails. | | |
| April 18 | N. Easterly | 240 | mod. | 70 lbs. | 59 tons | 14 | 1 | Welch Coal. |
| „ 19 | „ | 324 | light | 70 „ | 61 „ | 23 | 2 | |
| „ 20 | N.N.E. | 350 | „ | 65 „ | 64 „ | 24 | 3 | |
| „ 21 | N. Easterly | 340 | mod. | 65 „ | 65 „ | 24 | 4 | |
| „ 22 | Easterly | 315 | light | 65 „ | 65 „ | 7 | 5 | |
| „ 23 | S. Easterly | 313 | mod. | 65 „ | 65 „ | 20 | 6 | |
| „ 24 | S.E. to N.E. | 336 | light | 65 „ | 65 „ | 16 | 7 | |
| „ 25 | N.E. to S.E. | 329 | „ | 65 „ | 65 „ | 12 | 8 | |
| „ 26 | Westerly | 320 | „ | 65 „ | 65 „ | 3 | 9 | |
| „ 27 | „ | 196 | fresh | 65 „ | 58 „ | — | 10 | |

Queenstown to New York . . . 8 days 17½ hours.
Distance . . . . . 2850 knots.
Average speed per hour . . . 13·60 knots.

HOMEWARD VOYAGE.

| Date. | Winds. | Distance. | Force of Wind. | Pressure of Steam. | Coals Consumed. | Hours under Sail. | Days out. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 1872 | | | | | per diem | Sq. Sails. | | |
| May 5 | N.E. | 250 | mod. | 65 lbs. | 58 tons | 17 | 1 | American Coal. |
| „ 6 | Westerly | 300 | light | 65 „ | 64 „ | 8 | 2 | |
| „ 7 | S.S.E. | 310 | fresh | 65 „ | 64 „ | 12 | 3 | |
| „ 8 | S. | 307 | „ | 65 „ | 64 „ | 19 | 4 | |
| „ 9 | S.S.W. | 330 | mod. | 65 „ | 64 „ | 24 | 5 | |
| „ 10 | Westerly | 306 | „ | 65 „ | 64 „ | 24 | 6 | |
| „ 11 | „ | 300 | calm | 65 „ | 64 „ | — | 7 | |
| „ 12 | S.E. | 307 | mod. | 65 „ | 64 „ | 12 | 8 | |
| „ 13 | Easterly | 294 | „ | 65 „ | 63 „ | — | 9 | |
| „ 14 | „ | 284 | fresh | 65 „ | 61 „ | — | 10 | |
| „ 15 | „ | 102 | mod. | 65 „ | 29 „ | — | — | |

New York to Queenstown . . . 8 days 21 hours.
Distance . . . . . 2850 knots.
Average speed per hour . . . 13·38 knots.

We might prolong the paper to an indefinite length with a record of Mr. Laird's relations with the principal steamship companies of the United Kingdom, and his achievements in marine architecture. But our subsequent remarks on this phase of our subject must be very brief. Upwards of fifty steamers have been constructed at the Birkenhead works for river navigation in different parts of the world, besides some twenty-five specially designed for the navigation of the Indus, the Ganges, and the Amazon. In addition to vessels built for the National and the Pacific Companies, Mr. Laird has constructed large ocean-going steamers for the Peninsular and Oriental Company, for the Messageries Maritimes Company of France, and for the British Colonial Steam Navigation Company ; while he and his sons have built, besides the war vessels "Nemesis" and "Phlegethon," and the frigates "Guadaloupe" and "Birkenhead," gun-boats in wood and iron, troop-ships, mortar-boats, and iron-clad turret-ships for the English and foreign governments. In March, 1865, they launched the "Agincourt," an armour-clad of 6,621 tons B. M., for her Majesty's government, and two years previously they built the "Scorpion," an armour-clad turret of 1,827 tons and the "Wivern," an armour-clad built to the same line ; in 1869 the "Captain." For the Chinese Navy they have built the "Tien-tsin" and "Kwangtung." For the Peruvian Government they built the iron-clad turret "Huascar" (1,101 tons B. M.) ; for the Brazilian Navy they built the "Bahia" (1,008 tons B. M.), and the "Lima Barros" (1,330 tons B. M.), armour-clad turrets ; for the Dutch Navy they built the "Prins Hendrik der Nederlanden" (2,096 tons B. M.), armour-clad turret, and the "Krokodil" (1,589 tons B. M.), also "Heiligerlee" and "De Stier ;" while for the Argentine Government they have now on hand the "La Plata" and the "Los Andes," two armour-clads, each of 1,588 tons B. M.

The following is a complete summary of the vessels built by Mr. Laird and his sons from 1829 to 1873 :—

| Description of Vessels. | No. of vessels. | Tons. Builders' measurement. | Engine Power. Made at these works. Nominal horse. power. | Engine Power. Supplied by other firms. Nominal horse power. |
|---|---|---|---|---|
| Ships of war (including two iron-clad), broadside . . | 5 | 13,624 | 1,100 | 1,990 |
| Do. armour-clad turret . . | 10 | 17,951 | 3,070 | 300 |
| Gun boats . . . . . | 33 | 9,903 | 632 | 1,430 |
| Mortar boats . . . . . | 16 | 1,834 | ... | ... |
| Troop ships for H. M. Service . | 4 | 10,878 | 700 | 1,300 |
| Despatch, &c., &c., for do. . | 4 | 863 | 190 | 105 |
| For exploring expeditions. . | 7 | 1,811 | 160 | 175 |
| Steamers for the Hon. East India Co. (exclusive of gun boats). . . . . | 16 | 6,224 | ... | 660 |
| Troop vessels for the Hon. East India Co. . . . . | 5 | 2,562 | ... | ... |
| Steamers and troop vessels for Government of India. . | 15 | 16,020 | 448 | ... |
| Barge passenger vessels for use in India . . . . . | 8 | 2,264 | ... | ... |
| Steamers for mail-packet service | 15 | 30,814 | 4,100 | 3,540 |
| Do. for general steam trade . | 83 | 70,127 | 4,875 | 9,901 |
| Do. for river service . . | 57 | 16,680 | 2,500 | 1,411 |
| Steam launches and barges . | 18 | 757 | 270 | ... |
| Other barges and lighters. . | 35 | 1,527 | ... | ... |
| Steam dredgers. . . . | 3 | 786 | ... | 75 |
| Mud punts for do. . . . | 32 | 736 | ... | ... |
| Sailing ships . . . . | 24 | 17,482 | ... | ... |
| Yachts . . . . . | 9 | 1,305 | 183 | 15 |
| Tank boats . . . . . | 6 | 344 | 70 | ... |
| Light ships . . . . . | 2 | 348 | ... | ... |
| Pilot brig for Hon. East India Co. . . . . | 1 | 220 | ... | ... |
| Anchor boats . . . . . | 2 | 284 | 90 | ... |
| Caissons for docks . . . | 2 | ... | ... | ... |
| Mercantile steamers lengthened and increased in tonnage by | 17 | 4,318 | ... | ... |
| | 429 | 229,662 | 18,388 | 20,902 |
| Steam pumps, winches, &c. . | | | 500 | |
| | | | 18,888 | |
| ENGINES. | | | | |
| In addition to the engine power of 18,888 fitted in vessels built at these works, the following have been made there, to be fitted on board vessels built elsewhere, viz. :— | | | | |
| For the English Admiralty (nominal) . . . | | | 660 | |
| For the Egyptian Navy (nominal) . . . | | | 300 | |
| For mercantile firms (nominal) . . . . . | | | 5,295 | |
| | | | 25,143 | |
| Engine power supplied by other firms. . . . | | | 20,902 | |
| Total horse-power (nominal) | | | 46,045 | |

The above list was supplemented last year by the addition of eleven large steamers and 13,000 tons ; three vessels of over 2,000 tons aggregate have already been launched this year ; and other eight vessels are either in course of construction or contracted for. Within the last seventeen years the Birkenhead works have been extended so as to embrace the construction of marine engines ; and up to the end of last year the following engines had been built :—

| | Total Number. | Aggregate H. P., Nominal. |
|---|---|---|
| Paddle-wheel engines . . . | 52 | 6,285 |
| Screw engines, jet condensers . | 18 | 2,945 |
| „ „ surface condensers. | 8 | 4,400 |
| „ „ high pressure . . | 31 | 580 |
| | | 14,210 |

| | Total Number. | Aggregate H. P., Nominal. |
|---|---|---|
| Compound engines completed :— | | |
| Screw engines . . . . | 30 | 8,775 |
| In course of construction :— | | |
| Screw engines . . . . | 5 | 1,360 |
| Paddle . . . . . | 6 | 1,100 |
| Sundry steam pumps, winches, &c. | | 500 |
| | | 25,945 |

It is not too much to say that no shipbuilding firm in the world has made so many contributions to marine architecture. If all the vessels built by the Messrs. Laird could be brought together, they would form the most splendid fleet and the most imposing spectacle that could well be imagined, if indeed the imagination can at all grapple with the idea of over 440 vessels of all kinds and of all dimensions riding at anchor! To provide anchorage for such a fleet would exhaust the resources of the largest harbour in the world. Not even Liverpool, with its miles upon miles of dock accommodation, could make provision for it. And what a history is connected with these 440 vessels! They have not only assisted, step by step, to bring to its present high perfection the art of naval architecture. That is saying much, but far from enough. They have assisted to pull down and to build up empires, to give civilization a victory over barbarism, to bring together and to bind together by the strong ties of commerce and human sympathy, opposite ends of the earth, to make known the inheritance of the heathen, to solve important geographical and territorial problems, to give us maritime aggrandisement in the four quarters of the globe, and to establish on a basis that cannot be shaken the naval supremacy of Great Britain.

Such are some of the colossal results to which the Birkenhead works have contributed. But if we consider the value of these 440 vessels, we are met by scarcely less remarkable facts, for at the moderate rate of £25 per ton, 240,000 tons represent not less than six to seven millions sterling, as the turn-over of the Messrs. Laird since the first iron vessel was built at Birkenhead in 1829.

### The Birkenhead Ironworks.

The shipbuilding establishment of the Messrs. Laird at Birkenhead is distinguished for the admirable manner in which it is laid out. It is rather over eighteen years since the firm entered upon the present works, their operations having, previous to that time, been carried on in the original works on Wallasea Pool and in a branch establishment some distance farther up the river, on the site now occupied by the Herculaneum Dock. The most remarkable feature of the works is the series of docks, five in number, constructed for the repair and construction of vessels of every size. The dimensions of the different docks are as follow :—

| | | | Depth of water on a 20-foot tide. |
|---|---|---|---|
| No. 1. | 300 ft. long, | 40 ft. wide, | 18 ft. 3 in. |
| „ 2. | 270 „ | 45 „ | 18 „ 3 „ |
| „ 3. | 425 „ | 75 „ | 26 „ 0 „ |
| „ 4. | 440 „ | 85 „ | 22 „ 3 „ |
| „ 5. | 375 „ | 85 „ | 22 „ 3 „ |

Docks number three and five are covered with elegant and substantial roofs, and specially arranged for the building of iron-clad ships. Outside the entrances to the graving-docks, between low and high water-mark, a gridiron has been constructed for overhauling steamers. It extends a distance of 650 ft., and is formed on the solid rock. On the north side of the largest graving-dock there is a fifty-ton steam crane, used for lifting the engines and boilers into the vessels under construction. In doing this the vessel can be kept afloat, the docks being so arranged as to be used either wet or dry.

The operations connected with iron shipbuilding may be said to commence with the moulding-loft, which at the Birkenhead works is a large and spacious apartment, in which the dimensions of a vessel are traced on the floor, either at full length or to a certain scale. The lines and sections are drawn out with chalk. Some are distinguished by letters, and others by numbers. The sectional lines representing the frames of the ship about to be built are transferred from the floor to large boards, and these boards are in their turn taken down to the shop below, where the ship frames are bent, on perforated plates called levelling blocks, each measuring 10 ft. by 3 ft., and weighing several tons. In bending a bar of angle iron for the ship's frame, a small iron mould made from the lines on the large board, taken from the mould-loft, is placed on the blocks, and its outline drawn in chalk. The mould is then removed, and after pegs have been placed at intervals along each chalk line in the holes made for the purpose, the heated bar of iron is swung on to the block by crane power, bent to the pegs, and hammered to the required shape. The mould is then applied to the frame, which, when it is perfectly true, is removed to the punching press, to have the rivet holes made in each arm. The frames are then removed to the building slip, and manipulated into the skeleton of the projected vessel.

The engineers', smiths', and joiners' shops extend about 600 ft. along Church Street, on which they abut. The buildings are three storeys in height, and of most substantial construction. The depth of the buildings is about 60 ft. A line of railway enters the shipbuilding yard through a tunnel at the north-west corner, sweeping past the shops flanking Church Street, and round by the sheds on the south side of the yard. Lines of railway also lead to the three principal cranes, one passing between the timber yard and No. 1 graving-dock, another between No. 3 graving-dock and the first building slip, and the third connecting this branch with the fifty-ton crane. The engineers' fitting and erecting shops are three in number : the pattern and millwrights' shop on the second floor ; the fitting shop and light engineers' tools on the first floor, and the erecting shop and large engineering tools on the ground floor. The heavy machinery embraces some bending and punching machines of exceptional thickness, which are used at the present time to manipulate some six-inch armour plates intended for a couple of men-of-war vessels now on the stocks for a foreign Government. The armour plates are all brought from the works of Sir John Brown and Company, and Charles Cannell and Company, at Sheffield. In this department of the works, also, we notice some stern posts and crank shafts being polished and prepared for their places in the ships. These heavy forgings are usually done at works specially erected for that purpose. On the Mersey there are two large establishments, called the Mersey Forge Company and the Birkenhead Forge, which turn out a great deal of this class of work. But the Messrs. Laird do not confine their orders to the Mersey. Much of their work in heavy forgings comes from Scotland, where there are three of the largest forges in the kingdom—the Dennystown, the Lancefield, and the Parkhead ; but generally speaking, the firm, like most other shipbuilders, send out specifications of the work they require done to certain establishments on their selected list, and accept what seems to them to be the most advantageous and suitable. This class of work is paid for at a very heavy rate, ordinary stern posts and crank shafts costing £50 to £55 per ton, while in some cases forgings of a more special character cost £80 to £100 per ton. The heavy machinery at the Birkenhead works is of a superior class, and unites all the most recently devised improvements and economies. Powerful cranes are placed here and there throughout the fitting shops, which have an area of 70 ft. by 60 ft. The machinery is actuated by a forty horse-power single cylinder engine ; but to provide for emergencies, there is a spare engine capable of being used. The boiler makers have a shop with an area of 160 ft. by 60 ft., closely adjoining the fitting shops. The water used for feeding and testing the boilers is stored in a large cistern underneath the shop, and on the top of the building another large tank is placed. A third tank, containing a reserve supply of water, is provided at the north end of the works, and rests on the boundary wall. The boiler makers' shop is usually the most noisy part of a shipbuilding yard ; and any one who has passed through that branch of the Birkenhead works, will be likely to pause before he again encounters such a trying ordeal, and one so certain to induce headache. The boilers are put together in an extensive shed at the upper end of the yard, where machines for shearing, punching, drilling, and riveting will be found in operation. Formerly, it was usual to rivet by hand, a much more laborious process than that performed by the hydraulic and steam machines. In riveting boiler plates, they are suspended by an overhead crane between two dies, one stationary and another moveable. The rivets, after being placed hot in the holes, are brought one by one between these dies, and the moveable die is pressed forward with a force equal to upwards of twenty tons, thus fixing the rivet in its place. The smiths' and joiners' shops are placed in the centre of the main block of buildings abutting on Church Street, and measure 190 ft. by 60 ft. The smithy contains thirty-two fires, in four rows of eight each. Cranes are employed to lift the iron on to and off the hearths. The ordinary fan blast is communicated to the fires by underground pipes, and a large square tube, extending along the whole range of flues, conveys the smoke from two tall chimneys, one at each end of the works. The quantity of smoke produced is, however, very small, coke being almost the only fuel used for the smiths' fires. Another range of smiths' shops is placed on the south side of the yard. About the joiners' shops and timber store, set above the smiths' shops and measuring the same dimensions,

there are no features of special interest. Machinery is employed for nearly every process necessary in preparing the timbers for its functions in the vessel; and in passing through the joiners' shops, one cannot fail to be struck with the high finish given to the cabin fittings, the carving and polishing of which would generally do no discredit to furniture intended for the most gilded *salons* of London or Paris. The timber chiefly employed about iron ships is mahogany and teak, the latter being used as an inside lining for the hulls of armour-plated ships, and for the fitting of vessels intended for the Eastern trade, owing to its non-liability to shrink or expand by atmospheric influences.

The total area of the Birkenhead works is over twenty acres, and they are situated less than a quarter of a mile from Woodside Ferry, the principal means of communication between Liverpool and Birkenhead. All the buildings are separated from each other by fireproof partitions. In addition to the departments already referred to, the works comprise saw mills, drying-stores, rigging lofts, paint shops, and a dining-room for the workmen, measuring 60 ft. by 30, and fitted with the large cooking range which took the prize at the International Exhibition of 1851. In the latter adjunct of the works there are from 400 to 500 men dined daily. On the walls of the dining-room there are ranged little pigeon-holes, each having a number painted under it. When a man wants his dinner cooked, he deposits it in the pigeon-hole (the number of which corresponds with the number by which he is known in the works). In the course of the day it is taken out by the cook, and after passing through the necessary culinary process, replaced in the pigeon-hole, where the workman finds it when the dinner bell has summoned him from labour to refreshment. The dining-room is managed by a committee of the workmen, and the cook's expenses are defrayed by a weekly subscription of 2*d.* each collected by those who make use of the room. The total number of men employed about the Birkenhead works is about 3,000.

There is only one other feature of the Birkenhead works to which we propose to call attention, and although coming last, like a lady's postscript, it is, perhaps, the most interesting of all. We speak of the model room, in which are arranged models of all the principal vessels built by the firm. An inspection of these models will serve probably better than anything else to show the infinite variety of modes, forms, and shapes, employed in marine architecture, and the high degree of perfection to which that art has attained. Working models of all the vessels built by the Messrs. Laird are constructed and placed in this room, and here also we will find models of vessels that have never yet passed out of the region of speculation and theory. Some of the most interesting models are those constructed for the purpose of illustrating the system of revolving turret-ships with which the name of Capt. Coles is particularly identified. There are here also models of several vessels built with a patent feathering screw, the invention of Mr. R. R. Bevis, managing engineer to the Messrs. Laird, specially applicable to ships of war or other vessels designed to be navigated during a certain part of their voyage under sail alone. By this invention the blades of the screw can be set to any pitch, so that they do not interfere at all with the sailing of the ship. The plan designed by Mr. Bevis is much better, and far less cumbersome than the usual lifting gear. A number of these models were exhibited at the late Paris Exhibition, including those of the "Santa Rosa," a full-powered screw-steamer of 2,800 tons, and engines of 400 horse-power. Light three-masted schooner-rig, fitted with three side hatches on each side of the ship; built for the Pacific Steam Navigation Company. A small light draft paddle-wheel steamer of 100 tons, built of steel, and drawing 2 ft. of water, built for service in the river Amazon. The "More Vane," a large screw pleasure yacht for lake service and wild fowl shooting, built for the Marquis of Westminster. The "Heiligerlee," armour-clad twin screw light-draft monitor for coast defence, carrying one turret with two 300-pounder guns. Light pole-rig for signaling, built for the Royal Dutch Government. The "Stier," armour-clad twin screw steam ram for coast defence, carrying one turret with two 300-pounder guns. Light pole-rig for signaling, built for the Royal Dutch Government. The "Wyvern" (H. Britannic M.S.), armour-clad double turret steam ram, carrying four 300-pounder guns. Barque-rigged, and fitted with tripod masts on Captain Coles' system. The "Bahia," armour-clad twin screw light draft monitor, carrying one turret with two 300-pounder guns. Three masted schooner-rig, built for the Brazilian Government, and was engaged in the actions of the Paraguayan war. The Royal Mail Steamship "Britannia," full-powered ocean-going screw steamer of 3,700 tons, engines of 650 horse-power, barque-rigged, carries 3,300 tons dead weight of coal and cargo. Built for the Pacific Steam Navigation Company. A case containing ten of these models was exhibited at the late Vienna Exhibition and the various types of vessels represented; there being models of armour-clad turret vessels, large ocean-going merchant steamers, light draft river boats, steam yachts, and steam barges, each model representing a vessel actually built and at work.

### Public Career of Mr. Laird.

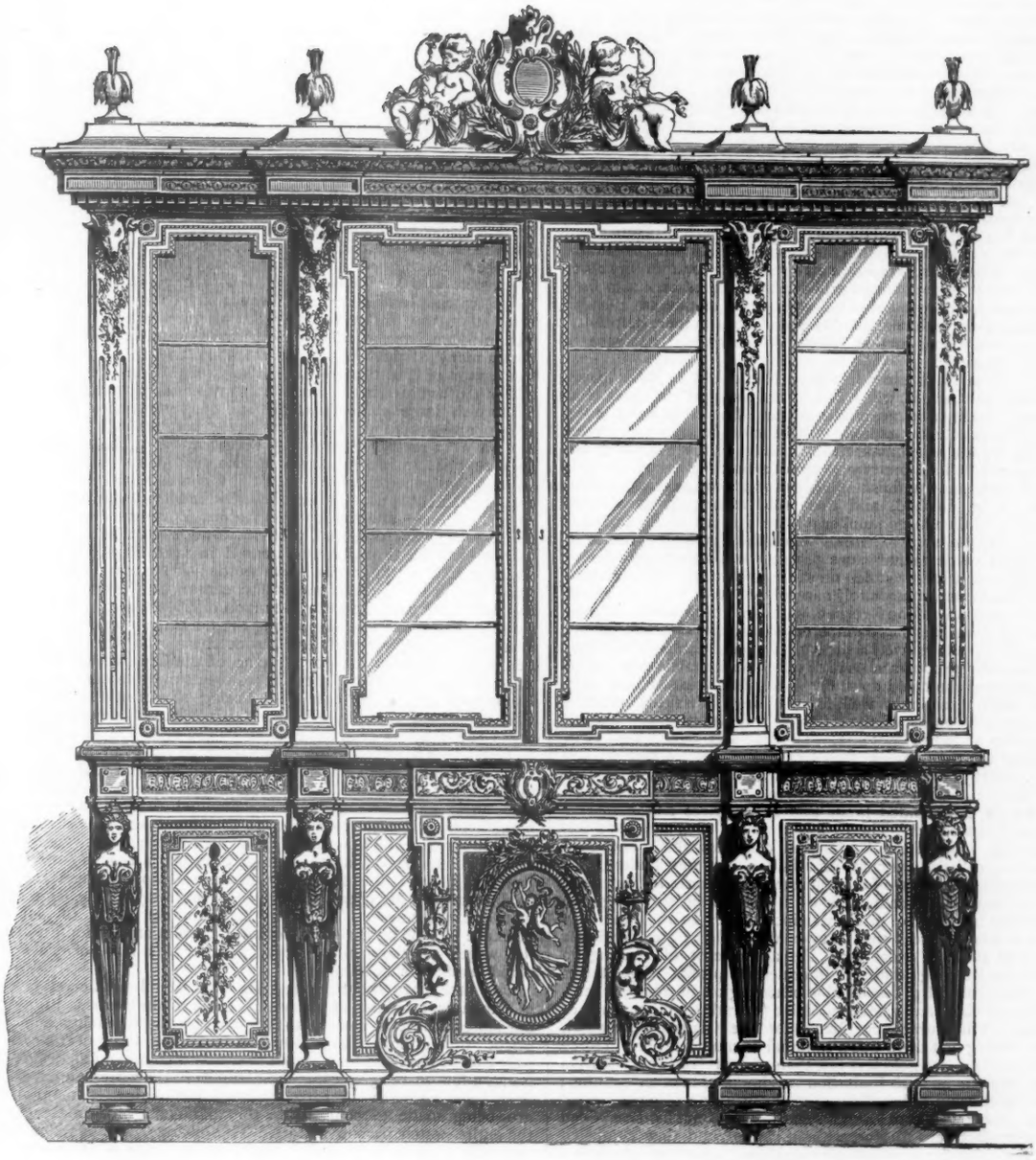
The progress of Birkenhead is as remarkable as that of any town in the United Kingdom. In 1831 it had a population of only 2,569. Ten years later its population was 8,223. In 1861 it numbered 36,000 inhabitants, and at the present time its population is about 70,000. The natural resources of Birkenhead are great; but they could not have been turned to such good account had it not been for the fostering care and public spirit of Mr. John Laird. It was that gentleman's father who first projected the Birkenhead Docks in 1827, and it was he himself who took that most active part in promoting the large extension of dock accommodation that has since taken place, and in getting Parliament to amalgamate the docks on both sides of the river in one trust called the Mersey Docks and Harbour Board. The first act for forming a local body to manage the affairs of Birkenhead was passed in 1833. Mr. Laird was one of the first commissioners named under that act, and for many years he acted as chairman of the commission. Birkenhead was made a Parliamentary borough in 1861, and Mr. Laird was elected its first member in December of that year. He was re-elected in 1865, 1868, and 1874. He has made several important speeches in the House of Commons, more particularly on naval matters, respecting which he can justly claim to be an authority. In 1857 Mr. Laird was presented with plate to the value of £600 by all classes in the township of Birkenhead, in testimony of the general approbation of his public services and private worth. Shortly before he had entered Parliament, Mr. Laird withdrew from private business entirely, and the Birkenhead works have since been carried on by his three sons.

## THE WATCH AND CLOCK MANUFACTURES, ENGLISH AND FOREIGN.

THE watch manufacture is in all respects an interesting one; alike in the wonderful ingenuity displayed by the inventors and workmen, in the great usefulness of the articles produced, and in the vast augmentation which labour gives to the money value of the tiny pieces of metal employed. Among ourselves, it is a branch of industry on which depends much of the prosperity of Clerkenwell, Prescot, and Coventry; among foreign nations it has become largely important to Switzerland, France, and the United States of America. English watch-making is, however, stagnant, even if not retrograding, in regard to the total value of the articles produced; and it certainly behoves those who are interested to ascertain why this is so. England took the lead of all the world in this manufacture some two or three generations back; if she does not still maintain the pre-eminence, can it be again secured? In rapidly glancing over the chief points illustrative of the subject we need not notice the exceptionally remarkable clocks and watches of which accounts have been printed, such as the skull, egg, crucifix, ring, coffin, walking-stick, crystal, duck-shaped, tulip, portrait, nautilus, touch, chatelaine, perpetual, liliputian, almanac, chanting, musical, giant, pedometer, astronomical, transparent, rose, acorn, agate, bracelet, magnet, eagle, jacinth, almond, apple, bird, book, melon, pear, one-hand, purse, reversible, self-winding, shell, snuff-box, segar, telescope, and waistclasp watches; nor the ocean, automaton, musical, griffin, alarm, inclined plane, aquatic, siderial, masquerade, ball, water, sand, nursery, vocal, wind, barometer, cuckoo, candle-lighting, time-map, bed, illuminated, paper, gun, cannon, time-beating, detonating, arithmetical, box-opening, camel, detector, lock, and loadstone clocks. We have only to do with ordinary clocks and watches, such as give rise to large industrial and commercial arrangements.

### Watch-Making in Switzerland.

Switzerland has never done much in the clock manufacture; but watches have for about two centuries received a large amount of attention from the hardy patient mountaineers of the little republic. A story has crystallized into an admitted historical fact that in 1665, a Swiss traveller, returning to his native canton of Neufchatel after a lengthened visit to other countries, brought home with him an English pocket watch, a thing never before seen in the secluded village of Locle, where resided a young mechanic named Daniel Jean Richard. The watch being out of order, Richard closely scrutinized it, found out the secret of its



GEMS OF INDUSTRIAL ART.—BOOKCASE, TEMP. LOUIS XVI.

CONSTRUCTED OF VIOLET, AMBOYNA, AND AMARANTH WOODS, AND MOUNTED WITH DELICATE BRONZES.

action, repaired it, and resolved to add watch-making to his other trades. He had great difficulty about tools; some he made himself, and others more or less suitable he picked up at Geneva one at a time. With the aid of his brothers and two or three apprentices he gradually established a trade. The watch he had first studied had a fusee cord of gut, but he substituted a fusee-chain; he added a pendulum spring, and by degrees fashioned a repeating motion and an alarum. Many new hands entered the trade, and the Neufchatel valley began to make rough chronometers, which were sold to firms at London and Paris for finishing. So matters went on until the present century. The apprentices served long enough to learn all branches of the trade, so that some of them could make a watch throughout. This system gave way, however, to a greater subdivision of labour; whereby no one man could make a whole watch, but each could make a greater number than before of pieces of some one particular kind. A decided step was taken when the production of horizontal watches established itself in Switzerland. These watches, invented in England, had the horizontal wheel made of brass and the cylinder of steel, to lessen the friction by using two dissimilar metals. The Swiss, rather as a matter of taste than for any other reason, used polished steel for both; they reaped an unexpected advantage, for they found that a steel wheel marks the cylinder much less quickly than one of brass, and leads to more durability. The horizontal construction, instead of the vertical, has been in favour ever since.

The Swiss trade extended from Neufchatel to other parts, especially to Geneva, which is now its head-quarters so far as concerns quality and mercantile favour. But Neufchatel is the largest manufacturing canton; at Chaux de Fonds nearly all the inhabitants are watchmakers. The kind of trade between the two cantons is kept pretty well secret from the public; but it is known that many unfinished Geneva watches are sent to Neufchatel to be finished, and then sold afterwards as Geneva watches; while a large number of others, made wholly in Neufchatel, bear the word "Geneva" when they have no claim to it. The Swiss watch manufacture generally was almost annihilated during the political troubles on the continent in 1848; not that those troubles fell immediately in a political sense on Switzerland, but because many of the foreign countries were too busily engaged in pulling down kings and emperors to think much about buying watches. Trade revived a little in 1849, and Switzerland found customers for 30,000 watches in 1850. The Republic determined to show what she could do at the Great Exhibition of London in 1851; this turned out well, for the English visitors admired alike the cheapness of the ordinary watches and the elegant decoration of ladies' watches. The sale was 50,000 this year. Building too much upon this fact, the Swiss worked on too rapidly in 1852 and 1853; they flooded the United States with their watches, which they consigned to agents in the large towns, and which commanded lower and lower prices as the market became overstocked. The Crimean war in 1854 and 1855 impoverished some of the continental countries which had until then bought Swiss watches, especially Russia and Turkey; the Swiss merchants sent off their accumulated stocks to America; and as Neufchatel competed with Geneva in so doing, the downward tendency of prices was increased. In 1856 and 1857 the glut was so great that watches were sold at New York for only four shillings more than the actual cost of making in Switzerland, saying nothing of intermediate profits. The Italian war of 1858 and 1859 disturbed another region of trade; whereupon the Swiss sent agents to drive a trade in other parts of Europe. This turned out badly for the Geneva gold-watch trade; seeing that there was a cantonal or municipal law in force to forbid the use of gold less fine than 18 carat (18 twenty-fourths pure), whereas no such limitation was imposed in other cantons; Neufchatel could sell gold watches cheaper than Geneva, simply because the gold was of lower standard. Discount banks enabled new manufacturers to start without capital, and they competed with the older firms to beat down prices; many Swiss watches were sold in London, Paris, and New York in 1861 and 1862 for less than they had cost to make. The best Geneva watches were still appreciated for their excellence; but the market for them was temporarily disturbed by the outpouring from Neufchatel. In 1858 a rough estimate had been formed that about 400,000 watches were annually exported from Switzerland, chiefly to or through France; that one-third of these were gold, averaging £4 each; and two-thirds silver, averaging £1 10s. But it is doubtful whether the means existed for obtaining trustworthy data; and as for the prices, they were unquestionably greatly disturbed by 1862.

In 1860 one of the secretaries of embassy gave a few particulars of the state of the watch trade at Chaux de Fonds. He stated that the gold watches made ranged from 55 to 75 francs in light cases, and from 150 to 200 francs in heavy; while the silver watches mostly varied from 20 to 25 francs (16s. to 20s.) Machine work was adopted for the rougher portions, in workshops at Fontaine, Nilon, Val de Ruy, and Beaucourt. Consul Mackenzie gave a little fuller account of the Swiss trade, so far as it related to Geneva, in 1864. America was the best customer at that time; Spain and Russia came next; England less than either. France was a purchaser for cheap goods, while Eastern Europe took many of the best kinds. We rather surmise, however, that there was a larger frontier trade between Switzerland and France than appeared in the consular accounts, so great was the tendency to mark and stamp bad watches as if they were among the better productions of the neighbouring country. English names and trade marks, properly applicable only to gold and silver cases, were made to do duty for movements as well, by the manufacturers of Neufchatel and Chaux de Fonds; such productions were sent to all parts of the world as English watches. The Geneva trade was known to be injuriously affected by the competition of Besançon (presently to be noticed), just across the frontier, where many large firms employed inferior hands at low wages to make cheap watches, in such quantities as to shut out a considerable percentage of Swiss goods. In a later notice, dated 1867, Consul Mackenzie said:—"With reference to the general quality of Swiss watches and jewellery, Geneva stands most decidedly first; then the Valley of the Lake of Joux, situated in the Vaudois Jura, from whence some of the Geneva manufacturers obtain many of their watch movements. Thence we come to the canton of Neufchatel—Locle, St. Croix, Chaux de Fonds, and other localities in the surrounding mountains; these places all furnish large numbers of average quality watches at low prices, giving rise to a considerable export trade. Another section of country, comprising Vorentray and the Bernese Jura, supplies an inferior class of watch, not guaranteed by the makers, and generally worthless." The commercial panic and crash of 1866, it appears, affected the Swiss watch trade as much as it had been affected by the various European wars and revolutions; exports fell off, profits and wages declined.

One queer kind of domestic quarrel in Switzerland we must notice in Consul Mackenzie's own words:—"Numerous Jewish firms established themselves in the canton of Geneva; they had left Neufchatel and the mountain district, where they had made a great many enemies among the working classes. These firms supply watches and jewellery at cheap rates for exportation, making use of the good repute of the Geneva workmanship; whereas, in reality, the watches they supply contain cheap Neufchatel works, the cases only being manufactured here. It is calculated that these Jewish firms sell and export eight times the amount of watches sold by the real Geneva manufacturers." To remedy this competition to Genevan industry, there are four or five Geneva houses which emulate each other in producing really good work, calculated to maintain a good position in any market. "It is computed that the Geneva manufacturers furnish from 28,000 to 30,000 watches annually, at average prices of 220 francs (£9) each; the Jewish firms deliver about 200,000, at an average price of 50 francs (£2) for gold and silver." We can easily understand how this flooding of the market with cheap trashy goods must injure the legitimate manufacturers. The trade had another cause of disturbance in 1868 by the efforts of the International to force up the wages of labour at Geneva, whether the state of trade could justify it or not.

One fact more about Switzerland. Mr. Rumbold, Secretary of Embassy, speaking of the watch trade of the Bernese Jura, has stated that it is now at so low an ebb (as to quality and prices), that, although large numbers are made, 10 or 12 francs only can be obtained for a watch that would command 25 or 30 francs a few years ago; while the earnings of the workmen have been reduced below those of common mechanics. Attempts are being made to concentrate the manufacture, by making the entire watch in one factory. This change, whether commercially successful or not, "would destroy one of the most interesting features of the Bernese watch trade; the system, namely, by which the workmen are allowed to make the parts of watches confided to them at home, and with the assistance of their families." It is to the credit of Switzerland, however, that the small republic maintains five horological schools, to which pupils are admitted at fourteen years of age, and remain four or five years; they are taught all branches of watch-making, are provided gratuitously with tools and working appliances, and have free admission to evening lectures on mechanics and geometrical drawing. The fee paid for these excellent advantages is very small.

What we learn, then, concerning the Swiss manufacture is—that a real Geneva watch may in all respects be an excellent one; that a cheap so-called Geneva watch is to some extent a sham, the movement having been made elsewhere; and that, in spite of the cheapness of living, Swiss watchmakers have often

a struggle to obtain a sufficiency of earnings. We may judge what low prices must be paid for labour in some instances, when we know that, at the present time, Swiss watches can be purchased in London for 15*s.*, or even 12*s.* 6*d.* each; and that China and Japan can obtain a particular kind made for that special market at the almost incredibly low price of 8*s.* each.

### Watchmaking in France and Italy.

It is not necessary to turn to any part of the continent north or east of Switzerland, for illustrations of the progress of this art; many curious specimens are produced, but none that belong to any highly-developed local industry. The same may be said of Italy, with the exception of a province which was Italian a few years ago, but now belongs to France, viz. Savoy. There was a National Exhibition held at Turin in 1858, the report of which comprised a notice of the Savoy watch manufacture. It appears that this branch of industry was established in the province as much as two centuries ago, but was not much developed until the early part of the present century. Many villages made and sold the movements of watches, which were afterwards finished in France, Switzerland, and other countries. Geneva and Neufchatel then took the lead, and the Savoy trade became much depressed. As a means of reviving it, schools of watchmaking were established in 1848, and these were so far successful that, in the course of the next ten years, the Savoyard watchmakers increased to 2,000 in number, producing watches to the value of 1,500,000 or 2,000,000 francs annually.

France is far more important than Italy in regard to watchmaking; indeed, one particular town, Besançon, ranks among the most remarkable centres in any foreign country. Paris, great as is its watch trade, makes very few watches throughout; it procures movements and other parts from various districts, and finishes them off for the market, generally in an elegant form. In the troubled times of the great French Revolution, about eighty years ago, nearly a hundred Swiss families of watchmakers, to escape the perils that menaced their native country, crossed the frontier and settled at Besançon, a town not many miles distant either from Geneva or from Neufchatel. For the first half century not much was heard of them as competitors among European watchmaking communities; but about 1845 Besançon claimed to be making 54,000 watches in a year, of which 9,000 were gold. From that time the progress of the trade has been surprisingly large. Taking the interval from 1850 to 1866, and specifying alternate years only, as being sufficient for our purpose, we find the following to have been the numbers of gold and silver watches made at Besançon in the years named:—

| | Gold | Silver | Total |
|---|---|---|---|
| 1850 . . . | 11,225 | 48,626 | 59,851 |
| 1852 . . . | 19,449 | 57,052 | 76,501 |
| 1854 . . . | 32,594 | 73,482 | 106,076 |
| 1856 . . . | 60,511 | 99,654 | 160,165 |
| 1858 . . . | 65,093 | 125,020 | 190,113 |
| 1860 . . . | 76,146 | 135,665 | 211,811 |
| 1862 . . . | 87,966 | 166,544 | 254,510 |
| 1864 . . . | 94,748 | 206,410 | 301,158 |
| 1866 . . . | 101,309 | 204,126 | 305,535 |

This rapidity of progress is really astonishing; the silver watch trade increased fourfold in sixteen years, the gold watch trade ninefold, and the two together fivefold. The statistics for 1868 showed that Besançon contained 105 workshops for cases only, employing six or eight men each; that there were 200 firms in all, and that many of them were employed in making up watches from the pieces made in the smaller towns and villages of the department of Doubs. The figures of more recent years show a further increase, but not in so great a ratio; the troubles of 1870 and 1871 affected Besançon as well as other French towns.

When the Society of Arts sent many skilled artisans to Paris in 1867, to examine and report upon the Grand Exhibition of that year, two of them, working watchmakers of Coventry, visited Besançon as well as Paris, and expressed their views as to what they saw. It somewhat anticipates our notice of the English trade, but it may be convenient to quote here the opinions of these two intelligent men, suggested by comparisons which their experience enabled them to make. They described minutely the School of Horology at Besançon, where the art is thoroughly taught in all its branches. Classes are held in a large building supplied by the municipal corporation; and these classes the students—or municipal apprentices, as we might not incorrectly designate them,—must attend for three years. Arithmetic, mensuration, geometrical drawing, and mechanical drawing, lay a theoretical groundwork from which the student advances to the practical processes of filing, turning, tool making, and all the departments of watchmaking. The students pay about £12 for the three years; and so complete is their drilling, that a youth on leaving the school can make every part of a watch—an achievement beyond the skill of any save a comparatively small number of full-grown men in England. One consequence of this excellent system is, that the 15,000 watchmakers of Besançon and its neighbourhood comprise an unusually large number of really skilled artisans. Our two reporters, speaking of watches made in different countries, and of the influence of horological schools, such as that at Besançon, said:—"The English watch is more durable and substantial, and less liable to get out of order than the French or Swiss watch; and is also, as a rule, a more correct timekeeper, owing to its having a fusee and lever compensation, instead of the going-barrel and cylindrical escapement of the French and Swiss watches. But the latter are produced at a much less cost, and consequently in much greater numbers. The advantages which the French and Swiss workers possess, and which conduce to this result, are chiefly as follow: The workmen are accustomed in their youth to receive instruction at horological schools, established for the purpose; by which means they have opportunities for acquiring a thorough knowledge of their trade, which English workmen do not possess. They have also paid more attention to the introduction of machinery and tools for facilitating the production of the different parts of a watch; and the work is more subdivided than in England." This seems to imply that although a Besançon workman *can* make all parts of a watch, the general custom, in France as in Switzerland, is to adopt the subdivision of labour very extensively. By these means they are enabled to produce at a much cheaper rate than the English can. They employ a much larger proportion of female labour than the English, though this remark applies more to the polishing than to the finishing. The Swiss manufacturers are allowed to make the cases to their watches of any quality of gold or silver they please, for all markets except France; while the English manufacturer must keep to the English standard.

### Black Forest and American Clocks.

The American watch trade was in part originated by a well-established manufacture of clocks; while the latter was an imitation, with improvements, of the European system. The clock manufacture we do not propose to notice in a complete form, because, on account of the larger size and less intricate mechanism of the article produced, it has not undergone such remarkable developments as the manufacture of watches. We may, however, say a few words of the clock manufacture of the Black Forest, and of that of the New England States in America, preparatory to a notice of the American production of watches.

The Black Forest has long been famous for its wooden clocks. Situated in Baden and Würtemberg, not far from the right bank of the Rhine, this forest occupies a long mountain range, and its trees yield abundance of good timber, which the inhabitants work up into toys, clocks, turnery, furniture, and implements of very varied character. The manufacture of clocks was begun on a small scale about two centuries ago; and even by the year 1796 the production was very limited; but it has greatly augmented since. The chief centres of the trade are Furtwangen and Neustadt; but the workers mostly live in scattered cottages, not in towns nor even in villages. The clocks sent to England have mostly weights and chains, and go twenty-four hours; Austria takes the best chain clocks, Italy spring clocks, Switzerland trumpet and cuckoo clocks, France clocks of large size; Holland and Belgium evince a liking for clocks having bronze cases ornamented with tin and porcelain, Russia for the best eight-day clocks, and Sweden and Denmark for clocks with hexagonal and octagonal cases. Thus the Black Forest, with its numerous and widely scattered workers, manages to suit the diverse tastes of all the nations of Europe. The number of operatives is variously stated; but the result of their labour is believed to be not far short of 600,000 clocks annually.

Crossing the Atlantic to America, we find that the New World had neither clock nor watch manufactures until the beginning of the present century; Europe was looked to for a supply. The fondness of the Americans for mechanism led them to enter into this branch of industry. In or about the year 1800 Eli Terry began to make clocks in Connecticut; when he had completed a few he strapped them upon and around his horse, and trotted round the country, selling his clocks as he went, and then returning home to make some more. They had wooden wheels and works; and being cheap, they were eagerly bought. Other manufacturers entered the trade, in Massachusetts as well as Connecticut. Judge Haliburton's Sam Slick is a capital example of the New England clockmaker and dealer, in the days before large factories were established. A great improvement was made by stamping the wheels out of sheet brass, instead of turning and carving them out of wood; and another by making the pinions of iron wire. After the example set by Eli Terry and

Seth Thomas, large clock factories were established in Maine and in New York, as well as in the States already named; Connecticut, however, continued to be the head-quarters of the trade. In 1869 it was stated that eight Connecticut firms turned out 440,000 clocks in a year, of which more than half were produced by two firms. Sold at prices ranging from one to ten dollars, and perhaps averaging two and a half dollars each, these clocks find their way all over the world. High-class clocks are not attempted; these are bought in England, because the wages of labour in the States are too high to encourage skilled hand-work where machinery can advantageously be employed. The shelf or mantelpiece clock, with a spring movement, and a spiral gong instead of a bell, has been a great success; it has come largely into favour, to supersede the old pendulum clock hanging up against the wall. Waterbury, East Windsor, East Hartford, and Plymouth are historically connected with the rise and progress of the American clock manufacture. It has been asserted on good authority that the employment of machinery has by no means destroyed the hand-work of American watchmaking. So great has been the extension of the producing power, that all the hands find ready employment; some in the factories, some in the production of dial-faces, jewels and other parts which cannot be made by machinery.

### Watchmaking in America.

We now come to American watches, a manufacture that depends more upon machinery than any watchmaking in Europe. No attempt was made to engraft this upon the clock manufacture, until a comparatively recent period. America bought and used watches from Europe, the larger number cheap from Switzerland, the smaller number superior, but dearer, from England. It was the difficulty of repairing Swiss watches when out of order that mainly suggested to the Americans the establishment of the manufacture in their own country. Whole villages in Switzerland are engaged in movement making, one village taking one part, one another, while others take the turning, drilling, &c.; these movements pass on to Geneva, Paris, and London, where they are adjusted, put into cases, and finished. It results from this system that each watch will have its own distinctive character; and that it is only by the merest chance that the movements of two watches can be found in exact correspondence, or that a piece once broken can be replaced by another exactly like it. From this want of similarity, and not from any deficiency in principle, arise the imperfections that are so annoying in the great majority of imported Swiss watches, and which render repair unduly costly compared with the original price of the watch.

The Americans, we have said, though willing to buy Swiss watches, were averse to the trouble and difficulty of repairing them. They therefore set about adapting some of their clock-making machinery to the manufacture of watches. Mr. Dennison, in 1850, established the Warren Watch Company at Brunswick, in the State of Maine; next to this was the Boston Watch Company, at Roxbury, Massachusetts. Finding Roxbury too dusty a place for the delicate mechanism of watches, the Company removed to Waltham, in the same State, where a new factory was built on the banks of the Charles River. The Company failed in 1857, and was succeeded in 1859 by another, which took the name of the American Watch Company. This establishment has since acquired much celebrity. The buildings occupy an area of 120 ft. by 100 ft., and are surrounded by a wide expanse of open ground, free from dust and interruption. Machinery is employed wherever possible, for the rolling of plates of brass, steel, and silver, drawing wire for pinions, pins, and screws, punching, swaging, cutting, polishing, burnishing, drilling. Jewels and jewel-holes are almost the only work not done by machinery. A gauge so small as $\frac{1}{10,000}$ of an inch, is employed in measuring jewel-holes and pivots. Any dial, plate, or escapement will fit one watch as well as another, seeing that all are cut with rigorous exactness. One uniform size is adopted for all the watches, $1\frac{3}{16}$ inches diameter. The fusee is rejected, as in most French watches, the motion being communicated directly from the barrel to the train. This change is advocated on the ground that there is greater simplicity of action, less friction in the transmission of motive power, increased facility for using a lighter and more uniform spring, and more room for play in the other parts of the movement. Some of the steel screws employed are so exquisitely fine that 100,000 of them weigh but little more than 1 lb. Not only are the jewels and pivots carefully classified, but the sizes used in each watch are notified by engraving beneath the number of the watch, so that any that may be broken can be easily replaced. It is estimated that four-fifths of the work are done by machinery, whereas in most European watches the proportion scarcely exceeds one-fifth.

In 1869 Mr. Ganney delivered a lecture at the Horological Institute, London (presently to be adverted to), on the American watch manufacture. He expressed a belief that the watches of the future will be machine-made. At the Waltham factory alone 70,000 or 80,000 watches are made in a year. On Monday morning sheet brass and steel wire are given out for some 1,500 watches, and by Saturday evening they are all finished. The uniformity of each kind of work, the certainty of the performances, and the non-liability to breakage, bring down the cost to a well-ascertained minimum; if dealers charge too high, the company would soon take retail sale into their own hands. Another good feature is that the names of the actual inventors of the various improvements in the watches present appear on the plates. The American law does not allow the name of any one but the actual inventor to appear, though of course the exclusive right to use his name and inventions he may part with to capitalists. This is certainly a much more just plan than the one followed in England, where a London shopkeeper causes his own name to be stamped on his wares, to the utter oblivion of the real inventor, so far as fame and honour are concerned. Mr. Ganney remarks, "Had we the seven large watch factories America now boasts, instead of finding our own markets filled with Swiss watches, and foreign markets filled with English rubbish, and Swiss work with English names forged on them, we should be the largest producers and exporters, as well as the most scientific inventors and perfectors of horological instruments for all purposes." By "English rubbish" Mr. Ganney must have meant the worst English goods, which some manufacturers are vainly trying to sell at a profit in competition with cheap Swiss.

A still more recent lecturer at our Horological Institute gave some further particulars of the American watch trade in 1873. It appears that at the Elgin factory, one of the largest in the States, as many as 500 watch movements can be made in one day, giving employment to 1000 hands; the building is large and systematic, comprising a machine shop, train shop, gilding shop, dial shop, engine shop, press shop, screw shop, escapement shop, balance shop, setting-up shop, &c. At another factory 600 hands turn out 5,000 watches per month; and it is there calculated that a watch takes thirty hours of labour, whereas a medium English lever takes seventy hours. Mr. Perkins, in answer to the question, What are the advantages of the machine system? replies, "The production of a mechanically perfect watch, and a great saving of labour. Be sure only that your model is right, and you may be sure that your classification will be correct also; there is no fitting and trying; the pieces brought from different parts of the factory will go rightly together. No finish has yet been attained by hand which is not attainable by machine."

### Clerkenwell and the English Trade.

We come at length to Clerkenwell, the head-quarters of the English watch and clock trades, passing allusions to which occur in many of the foregoing paragraphs.

How long the manufacture has been settled in that locality is not known; but that the watch trade in its higher development belongs to England is certain. At a time when nothing beyond very poor watches were made in any part of the Continent, English horologists had risen to great fame, and a real English watch or chronometer carried its passport with it to any part of the world. So far as Clerkenwell is concerned, we know that a celebrated maker lived and worked there a century and a half ago. This was Christopher Pinchbeck, a skilful maker of automaton and other curious watches, and the inventor of the useful and brilliant metal called after his name—a metal composed of four parts copper and three zinc. A newspaper advertisement of 1721 tells us that Pinchbeck "maketh and selleth watches of all sorts, and clocks as well for the exact indication of time, such as astronomical for showing the various motions and phenomena of planets and fixed stars, solving at sight several astronomical problems; besides all this a variety of musical performances, and that to the greatest nicety of time and tune, with the usual graces. Together with a wonderful imitation of several songs and voices, an aviary of birds, so natural that any who have not the instrument would be persuaded that it were in reality what it only represents. He makes musical automata or instruments of themselves to play exceedingly well on the flute, flaggelet, or organ, setts of country dances, minuets, jiggs, and the opera tunes, or the most perfect imitations of the aviary and birds above mentioned." Clearly Christopher Pinchbeck must have been an exceptionally clever mechanician, belonging to the school of Vaucanson and Wolfgang de Kempelen.

Clerkenwell has grown and amplified to what it is by insensible degrees. It is a veritable hive of watchmakers, clockmakers, and chronometer makers, jewellers, goldsmiths, and silversmiths. Go where we may, penetrate into whatever quiet street we like, there we find indications of this fact; not many open shops, but private houses with workshops in the rear, or workrooms from kitchen to garret. One man, a man and his son, a man and an apprentice, a master with five, ten, twenty, or more workmen—all these varieties, but very few establishments large enough to

claim the name of factories. Percival Street, Spencer Street, Clerkenwell Close, King's Square, President Street, Rosoman Street, Lever Street, Compton Street, Northampton Square, St. John Street, Ashby Street, they all bear a family resemblance, though some put on the air of a little more gentility than others. Judging from the inscriptions on doors and windows, or still better by a reference to the Post Office London Directory, we see how numerous are the subdivisions into which the above-named trades are broken up. Leaving out jewellers, goldsmiths, and silversmiths, as lying beyond the scope of the present article, we find that the clock manufacture is divided into clock-makers, clock-case makers, church clock makers, wooden clock makers, musical clock makers, clock chain makers, clock glass makers, clock tool makers. But this is as nothing compared with the subdivision of the watch and chronometer manufacturers. Here we find, besides watchmakers and chronometer makers as undivided entries, the more special trades of watch balance makers, watch barrel makers, watch cap makers, watch jewel gauge makers, watch dial makers, watch dial finishers, watch enamellers, watch engine turners, watch engravers, watch escapement makers, watch examiners, watch finishers, watch fusee makers, watch gilders, watch glass makers, watch hand makers, watch jewellers, watch joint finishers, watch key makers, watch material dealers, watch motion makers, watch pallet makers, watch pendant makers, watch ruby pin makers, watch secret springers, watch spring makers, watch tool makers, watch wheel makers. These, it must be remembered, are all master trades; the actual workmen are still more separated and subdivided in the parts of the labour which they undertake. Mr. Wood, in his "Account of Clocks and Watches," says that "A good three-quarter plate watch, as usually made, requires 138 distinct pieces in its frame, train, escapement, potence, fusee, arbour clicks, wheels, and other nicely constructed and adjusted constituents. To these appliances must be added the chain, which contains 63 links and 42 rivets to every inch; and being generally six inches in length, it comprises 638 pieces, thus swelling the contents of a common detached lever watch to 768 separate pieces. To construct these gives occupation to no less than forty-eight or fifty different kinds of artificers." Mr. Wood does not explain how he reconciles the two statements, but in one place he declares that "there are 102 distinct branches, to any one of which a boy may be apprenticed." We cannot help thinking that some error, clerical or typographical, must have crept into these figures.

Clerkenwell has not been wholly neglectful of the advantages of machinery; although the majority did not back up the proceedings of the minority, a "British Watchmaking Company" was established in or about 1840, and a factory stored with very good machinery; but the working capital being small, and the opposition in the trade generally very fierce, the scheme fell to the ground after a brief existence. Clerkenwell has established a Horological Institute, which gives lectures, reads papers, carries on discussions, offers prizes, and publishes a "Horological Journal;" it is small and slenderly supported, but has been the means of disseminating much information useful and interesting to the watch and clock trades. Prescot in Lancashire produces a large portion of the movements for the Clerkenwell watches; machinery is employed to a considerable extent in making them; but the Prescot folk do little more than the movements, leaving the watchmakers (so called) to do all the rest. These watchmakers purchase nearly all the parts from the small masters already mentioned, including the movements for the better kind of watches; and there is much running about from one part of Clerkenwell to another to collect together the bones and sinews and joints of the delicate organism. Clerkenwell does much of the work for which credit is taken by Cornhill and Cheapside, Ludgate Hill and the Strand, Regent Street and Oxford Street, Bond Street and St. James's Street; the purchasers of watches at the glittering shops do not know, and are not expected to know, how much of the work comes from a far quieter neighbourhood. It is not too much to say that Clerkenwell may be credited with some of the best watch work in the world, albeit the praise, or a large percentage, goes to other regions.

### The Struggle for Supremacy.

Yet it is a fact that Clerkenwell, notwithstanding the excellence of the work and the increase of population in the Metropolis, increases its trade but slowly. Statistics of the trade for fourteen years were collected in 1864; it related to the whole of England, and the following figures will show how little advance was made in a period which witnessed the doubling and trebling of so many branches of our ornamental manufactures:—

| | Gold. | Silver. | Total. |
|---|---|---|---|
| 1850 . . . | 22,272 | 93,528 | 115,800 |
| 1851 . . . | 25,509 | 96,689 | 122,198 |
| 1852 . . . | 27,871 | 97,475 | 125,346 |
| 1853 . . . | 31,307 | 109,502 | 140,809 |
| 1854 . . . | 31,249 | 116,397 | 147,646 |
| 1855 . . . | 29,621 | 118,492 | 148,113 |
| 1856 . . . | 34,453 | 128,224 | 162,677 |
| 1857 . . . | 40,542 | 138,005 | 178,547 |
| 1858 . . . | 34,263 | 113,173 | 147,436 |
| 1859 . . . | 40,338 | 115,279 | 155,617 |
| 1860 . . . | 37,588 | 129,002 | 166,590 |
| 1861 . . . | 35,390 | 117,165 | 152,555 |
| 1862 . . . | 34,507 | 102,246 | 136,753 |
| 1863 . . . | 36,906 | 105,714 | 142,620 |

Of these watches made in fourteen years, 318,923 gold and 1,139,704 silver were hall-marked at the London Assay Office; 4,179 gold and 199,155 silver at that of Birmingham; 138,714 gold and 241,632 silver at that of Chester. We see that those of 1862 and 1863 were only just about equal in number to those of 1853 and 1854, and decidedly less than those in the intervening years. The value may probably vary from time to time; but in 1858 there was an estimate that English gold watches averaged £10 each, and silver £3; these were probably wholesale prices, for those of the retail shops would certainly be higher. Discussions at the rooms of the Horological Institute, to which we shall presently advert, tell not merely of a stagnation but a real falling-off in the number of watches made; from which we infer that the numbers from 1864 to 1874 would not stand out satisfactorily.

Watch buyers, as a class, undoubtedly look to decorative exterior as well as to internal excellence; and an opinion has been expressed that our makers do not attend sufficiently to this matter. It appears that the Swiss manufacturers notice attentively the style of decoration that suits foreign markets. For instance—for France the general style is a small bouquet, or a shield with a few flowers and a very narrow border; this is also the style for Italy, together with a fancy pattern of engine-turning; for Germany, heavy ornaments with but little engine-turning; the Russian taste is similar, intermixed with jewellery and enamelling; the Spaniard likes Scripture subjects, diversified with bull fights; Turkey and the East most admire flowers, with the watch cases decorated both outside and inside; naval subjects are the current taste for the United States, sometimes varied with gold-digging scenes; while Mexico and South America evince a liking for saints and Scripture subjects, intermixed, however, with buffalo hunts and cock-fights. But if our watchmakers have been somewhat remiss in regard to these ornate affairs, they must be credited with those excellent specimens of substantial work which are called for by the exigences of the times—such as the railway watch. The great increase of railway travelling suggested the construction of watches not likely to be injured by shaking; this has been effected by dispensing with detached and duplex escapements, and using strong levers, heavier balances than usual, and thick glasses.

We have stated that discussions have taken place, and papers read, at the Horological Institute, on the state of the English trade, the causes that have led to depression, and the best mode of introducing a remedy. On one of these occasions Mr. Ganney remarked,—"It is anomalous when we know that the number of watches sold and worn in this country has been steadily increasing, while the number manufactured here has been as surely declining during the last few years. The probable causes are, (1), The introduction of Swiss watches in extraordinary number and great variety, to suit the taste and means of all classes of purchasers; (2), Dishonest trading, Swiss watches being sold abroad as English. Considering that an English watch comprises 800 to 900 pieces, while a Swiss watch has only 80 or 100, the former must necessarily be the dearer; (3), The use of a simpler escapement in Swiss watches, which English makers would do well to study; (4), The lower wages of labour in Switzerland than in England." On another occasion Mr. Jones said, "The Swiss are encroaching upon us." In answer to the question, "How is this?" he expressed an opinion that they do it by adopting an elegant style of work, which satisfies a class to whom form and beauty are the chief requirements; and, more reprehensively, by stamping our names on watches not made by us. The main fact is that the Swiss sell a cheaper article. "The English lever is a better manufacture than the Swiss cylinder; but the time-keeping qualities, irrespective of durability, are sufficient in the moderately good Swiss watch. The London trade recognizes more small independent masters than the Swiss trade; and the profits of these several trades swell the aggregate price. The London men, whose work is good and judgment true, may still keep their prices for best work; but the bulk of our trade must be obtained by employing men whose wages approximate more to those of the Swiss." Not a pleasant suggestion this for the interests of skilled English workmen.

Concerning the actual imports, the Board of Trade, for reasons left unexplained, gives the number as well as the value of the foreign clocks imported, but of watches the value only without the number. This difference renders the means of comparison incomplete; but making the best of the data supplied, we have constructed the following table of imports for the last seventeen years:—

| | Clocks | | Watches |
|---|---|---|---|
| 1857 . . | 266,545 = | £146,989 | £209,380 |
| 1858 . . | 247,628 = | 134,483 | 211,441 |
| 1859 . . | 276,949 = | 161,071 | 213,561 |
| 1860 . . | 343,362 = | 219,396 | 346,798 |
| 1861 . . | 270,295 = | 219,596 | 331,565 |
| 1862 . . | 247,263 = | 200,242 | 263,769 |
| 1863 . . | 314,291 = | 256,209 | 256,363 |
| 1864 . . | 375,922 = | 270,225 | 237,208 |
| 1865 . . | 231,356 = | 216,277 | 256,076 |
| 1866 . . | 254,534 = | 255,879 | 257,414 |
| 1867 . . | 251,355 = | 263,291 | 189,183 |
| 1868 . . | 241,246 = | 277,358 | 198,856 |
| 1869 . . | 330,412 = | 319,008 | 199,207 |
| 1870 . . | 256,861 = | 258,628 | 372,420 |
| 1871 . . | 325,667 = | 373,572 | 469,704 |
| 1872 . . | 373,625 = | 438,110 | 351,150 |
| 1873 . . | 403,183 = | 425,741 | 407,284 |

We here see that, in the last three years, the average for clocks and watches together is about £800,000 annually.

Discussions at the Institute of more recent date have presented the same general character. Mr. Adam Thomas on one of the evenings observed:—"We cannot prevent men from buying in the cheapest market, but we may be able to teach them that it would be wiser to buy better things. It is for the English maker to show that he can make better things at a moderate advance upon the prices of his competitors. The Swiss will be able to beat the English in cheapness at all times, unless changes take place which no man can anticipate. It will therefore be well to leave the cheap markets entirely to them. There is no merit in making this concession; it is nearly in their hands already." Sir John Bennett declared that, "The number of watches manufactured in Switzerland is so overwhelming as to swamp the sale of second and third-class watches in every foreign market; while there is a steady and progressive increase in the sale of Swiss watches in every principal town in England. Every watchmaker's experience puts this beyond dispute."

Coventry has rather an extensive watch manufacture, chiefly of the cheaper kind. Mr. Ganney has made some home-thrusts both at that town and at the London dealers, as producing results injurious to the Clerkenwell trade in its best features. Of the former he remarks, "Coventry, I am sorry to say, has not distinguished itself in connection with horological manufactures. It seems to be so ashamed of its own productions, that it never puts the city's name upon them; and, it would seem, instead of producing sound, plain honest watches that would uphold the English name for economy of production, strength and durability, they have flooded America and other parts of the world with worthless imitations of first-class London work, the demand for which they have nearly destroyed." Lest Coventry should feel aggrieved at these words, it may be well to show that the lecturer hit equally hard at the London shopkeepers: "The London retail trade is now dominated by individuals who are mere traders, buying in the cheapest and selling in the dearest market. The English manufacturer being the trader's subordinate, he can neither enlarge his operations nor obtain an appreciation for his merits as a return for his investment; the vendor being interested not so much in the durability of his wares, and the securing of a genuine reputation as an horologist, as on a rapid sale and frequent return for repair, which, with many vendors, is the most valuable portion of their business. Had our manufacturers wholesale and retail depots for the sale of their work in our chief thoroughfares, they might with advantage dispense with the crumbs they now receive from the London vendors, and secure a sale for their watches both in town and country. The country dealers would be glad of agencies enabling them to supply their neighbourhood with London watches in which the public could feel confidence; instead of those neighbourhoods, as is now too often the case, deceived by false advertisements, obtaining foreign work with the London trade-mark upon it."

Some watchmakers, then, advise Clerkenwell, as the headquarters of the London trade, to adopt machinery as much as possible; some advocate the employment of less skilful workmen at lower wages, to compete with Switzerland in cheapness; some advise an abandonment of cheap work altogether, and a reliance on well earned fame as the producers of the strongest and most durable watches in the world; some suggest the advisability of a simpler form of construction than is usually adopted, cheaper because simpler, but not through slovenly workmanship; some would interdict, if they could, the engraving of London names and marks on Coventry work; while others denounce the dealers and shopkeepers for lending themselves to the same kind of deception as regards London marks on Swiss watches as well as Coventry. Mr. Holdsworth, in a lecture at the Institute in 1867, broached an opinion that co-operation, which has succeeded so well in some other trades, might perhaps be practicable in this. "The great difficulty in undertakings of this kind is to get a sufficient number of working men to make a beginning; but could we by any such means succeed in obtaining a sum which would enable us to make a fair start and live on until the enterprise takes root we shall then find it pretty plain sailing." Meanwhile, the Horological Institute has been doing a little, with its limited means, to set ingenuity to work. It has offered prizes for the best English-made going-barrel movement that can be sold in fair trade at a moderate price; no patent of exclusive right, but to be presented in the name of the Institute to the trade in general. Also a prize for the best practicable scale for minute measurement, a standard gauge by which all workmen and workshops may correspond and agree with each other to the $\frac{1}{100}$th or $\frac{1}{1,000}$th part of an inch, producing a nicety of work among all the workers who adopt it. The Institute has, we believe, been likewise instrumental in awarding a prize for the best practical Essay on one of the most important parts of watchmaking, given by a lady whose name is associated with so many noble and benevolent works—the Baroness Burdett Coutts.

We may mention that the northern metropolis supports an "Edinburgh Horological Society," at the meetings of which many instructive papers are read and discussed.

## A TREATISE ON THE MANUFACTURE OF GENUINE WINES.[1]

### PART II.

### THE NOSOGRAPHY OF WINE.[1]

### 13.—THE AFFECTIONS AND DISEASES OF WINE.

"WELL-MADE wine never turns bad." This very positive doctrine is laid down by Count Odart, and is supported by the opinion of M. Guiot. We prefer to restrict ourselves to the assertion that *well-made wine sickens rarely*, and only through age, so long as it is subject to the conditions which science has shown to be necessary to its safe keeping.

The experience of growers in ancient and modern times, and the recent researches of the ablest œnologists, alike afford ample proof that the constitution of the very best and most perfectly made wine is *not* immutable. Wine is a compound solution of many complex organic principles, which never are in a state of equilibrium sufficiently stable to render it wholly independent, either of divers disturbing influences—mostly external—which affect it injuriously and may even destroy it, or of certain chemical reactions which are constantly recurring between its constituents with a degree of intensity depending upon the physical conditions to which it is subject.

We all know that wine does not remain unaltered for an indefinite period. Year by year it changes and acquires new properties. Principles, the presence of which was sufficiently palpable at first, become wholly or partially eliminated, as in the case of the *tartar*, *tannin*, *colouring matter*, and *organic substances* held in suspension in newly-made wine; at the same time, new principles, resulting from modifications of the former, manifest themselves by degrees. During a certain period, of varying duration in different wines, these internal changes improve the wine and add to its value. After that period they lead to its deterioration, and, ultimately, to its destruction. Such is the ordinary vital round of every wine—a period of juvenescence—maturity, when its best qualities are revealed—then come decadence, and death. But of these changes, to which every wine is subject for a period of longer or shorter duration, it concerns us not to speak here. Our present purpose is to consider certain *abnormal* changes, which affect the constitution of wines in an irregular manner, rendering them unfit for consumption, and which are generally denominated the *diseases* or *maladies* of wine.

And here, at the outset, it is necessary to recognize the distinction between the *defects* and the *diseases* of wine. Wine may be defective in quality owing either to the deficiency or to the

[1] *Tratado de Vinificação para Vinhos genuinos.* Pelo Visconde Villa Maior. 2 parts. Lisbon. 1869. [Translated by H. M. Chichester, Esq.]

excess of certain essential principles, or to the presence of others which properly are foreign to its constitution, and yet it may be wholesome and fit for use. Want of body, excess of colouring matter, a deficiency or excess of spirit, too great astringency, bad colour, want of bouquet, the presence of a peculiar smell or taste, such as arises from the use of casks made of new wood, or from the resinous substances which in some places are employed to coat them; all these are defects, natural or artificial, but none of them deeply affect the composition of any wine, nor do they lead to its utter deterioration.

Disease, on the contrary, produces a deep-seated disorganization of the affected wine, by destroying the equilibrium, so to speak, of its constituent principles, decomposing some of them wholly or in part, and destroying others, thus rendering it unfitted for alimentary uses.

Such are the *acetation* of wine, in which the alcohol becomes at first anhydrous, and eventually turns into acetic acid or vinegar; "turning" or "rising," which with improperly kept wines often shows itself during the first warm days of spring, or later in the season, producing decomposition, and, if not checked in time, putrescence; "bitterness," to which Burgundy wines are especially subject; "ropiness," or *mucous fermentation*, which frequently makes its appearance in white wines deficient in tannin; and "agre-doce," or "sour-sweetness," a malady common in wines containing much saccharine matter or made of grapes irregularly ripened in very hot years; besides many others which have hitherto been very imperfectly observed, and still less completely described.

In the succeeding chapters we shall speak principally of those maladies which have been made the subject of careful observation, not omitting an occasional glance at some of the most common defects in wine. It must, however, be remarked that the diseases of wine constitute a subject which has been very much neglected, and that the modes of treatment hitherto advocated have been uncertain, and for the most part empirical. It is necessary to call the attention not only of growers, but of merchants and dealers in wine generally to this matter, as they have it in their power to furnish œnologists with the largest possible number of carefully-made observations upon the nature of the exciting causes of the changes in question, and the most suitable modes of prevention and cure.

Many Portuguese writers of repute have treated of the maladies of wine, but, with the single exception of M. J. I. Ferreira Lapa, in the first part of his "Technologia rural," (chap. ix. *Defeitos e doenças dos vinhos*), none have handled the subject with the fulness, perspicuity and method which it demands.

Alarte, in his "Agricultura das Vinhas," devotes a chapter (No. XXVIII.) to the consideration *Dos remedios para tirar os vicios do vinho depois de cozido.* The title itself is proof sufficient of the unscientific manner in which the question is discussed. He gives no descriptions of the maladies to which wine is subject, but confines himself to the prescription of certain remedies—all of them empirical—for what he terms *podridão* (putrescence), *azedume* (acetation), *mofo* (mouldiness), *gordura* (greasiness or ropiness), and *turvaçao* (rising).

In a memoir on "A Cultura das Vinhas," &c. drawn up and presented to the Royal Academy of Sciences, Lisbon, by José Verissima Alvares da Silva, and first printed in 1787, a few pages of one chapter (No. 4) are devoted to the consideration of the ailments of wine, especially, *azedume* (acetation), *perdimento do espirito* (loss of spirit), *gordura* (ropiness) and *turvaçao* (turning).

Amongst the *Agricultural Memoirs* printed by the same Academy in 1790, is one by Francisco Perreira Rebello da Fonseca, the twelfth chapter of which treats *Da conservaçao do vinho, das suas doenças e remedios.* The writer advocates certain unaccepted and rather unintelligible theories, and restricts himself to the consideration of three diseases, *azedume*, *gordura* and *turvaçao.*

Another memoir, presented to the academy at the same period by Vincinte Coelho Seabra da Silva Telles, in par. 51, makes mention of four maladies, *azedume*, *podridão*, *gordura* and *turvaçao.*

In all the above works, the modes of diagnosis, like the theories broached to explain the presence of diseases in wine, and the major part of the remedies suggested for them, scarcely deserve criticism, and are very far indeed from satisfying the requirements of this branch of œnological science. Nevertheless, we shall extract a few passages from them when it is possible to apply them advantageously to the subject in hand, as it is not meet that the labours of writers so deservedly held in esteem should be passed over as utterly valueless.

In the *Tratado theorico da Agricoltura das Vinhas* of the Viscount de Villarinho di S. Romao we also find in one chapter (No. XXIII.) reference to three diseases, *azedume*, *gordura* and *turvaçao.*

M. Ferreira Lapa, in his work before referred to, discusses the subject more fully than any of the preceding writers: he recognizes the distinction between the *defects* and *diseases* of wine; he specifies and describes them separately; he enumerates the causes which originate or appear to originate them, and the remedies which have been proposed for them. The simple *defects* of wine he divides, for the sake of greater perspicuity, into *congenital* and *acquired defects;* and he particularly describes the following diseases—*turvaçao*, *gordura*, *azedume*, *podridão*, (putrescence) *azulado* (a peculiar change of colour), and *agre-doce* (sour-sweetness).

Turning to the writings of foreign œnological authorities we find, numerous as they are, that they do not satisfy the inquirer, and we feel compelled in the end to admit that the nosography and therapeutics of wine are still in a very obscure and unsatisfactory state.

The recent researches of M. Pasteur are, incontestably, the most important step which has yet been taken in the right direction. Hitherto, both scientific and practical men have contented themselves with the acquisition of data bearing upon isolated facts, without attempting to establish between them a theoretical bond of union which might facilitate the progress of investigators in the way that leads up from the study of effects to the recognition of causes, and thence to the detection of the means of prevention. It is for œnologists to pursue this way tentatively, in the assurance that sooner or later they must arrive at that positive knowledge of the causes of the diseases of wine, without which they are evidently incompetent to decide upon the proper means of counteracting and preventing them.

M. Pasteur's theory, based chiefly on the microscopical study of the sediment of affected wine, is simple, and narrows the question to the limits of the following proposition, viz.—the morbid changes to which wine is subject are of a fermentaceous character and are the work of organisms analogous to the ferment which produces wine itself. Whence it follows, as a logical sequence, that if we can discover some means of destroying these organisms or ferments without impairing the essential properties of the wine itself, we shall have a remedy for the diseases of this valuable aliment. According to M. Pasteur this may be effected by raising the wine to a temperature of 120° to 140° Fahr. without exposure to the air. His views have been partially confirmed by experiment, but not so fully as to justify us in accepting them without certain reservations.

As it seems highly desirable that our growers and traders should be made acquainted with these important practical questions, which so intimately affect the durability and reputation of an article ranking highest in commercial value amongst our agricultural products, we shall treat the subject as fully as its importance demands, beginning by setting forth, in relation to each of the chief diseases of wine, the views respecting it which appear most worthy of acceptance.

*Acetation* (o azedume), *turning* (turvaçao), *bitterness* (amargor), *ropinesss* (o engorduramento), and *sour-sweetness* (agre-doce). These are the principal and most common phenomena which, in the opinion of the majority of œnologists, are calculated to exert a radically injurious influence upon wine. We shall treat each of them separately, in the order above indicated, regarding them from a stand-point in unison with the spirit of modern science.

### 14.—ACETATION.

*Acetation* or *acidification* is one of the most common diseases of Portuguese wines. It reveals itself, principally, by a vinegar-like odour and taste, of which the chief element is acetic acid, and, as a general rule, it is preceded by the appearance on the surface of the liquor of a species of cryptogamic vegetation popularly known as *flowers of wine* or of *vinegar*, accompanied by the presence of a swarm of little gnats.

The acetic acid is obtained from the alcohol by a process of slow combustion, *i.e.* by oxygenation—in other words, the alcoholic portion of the affected wine is turned into vinegar by the agency of the oxygen in the surrounding air. This influence would appear *not* to be exerted directly, as pure alcohol, however much diluted with water it may be, never turns acid by contact with oxygen or atmospheric air, so long as the latter are free from impurities.

Pure and strongly-alcoholic wines, like the fine, ripe, full-bodied wines of the Douro, never turn acid readily. On the other hand, ordinary and inferior wines, containing much nitrogenous matter offering a suitable *nidus* for ferments, when exposed to the air at a medium temperature, are extremely subject to acetation. Hence it would seem that the intervention of some foreign matter, not an essential part of the wine itself, is necessary to the development of that acetic action which ends in the conversion of the latter into vinegar. All the observations which have been made upon this subject by the most competent scientific and practical men tend to prove that the transmuta-

tion of the wine into vinegar is due to a species of fermentative action known as *acetic fermentation*. Just as in the *alcoholic* form of fermentation, a certain organism, by the exercise of its vital functions, transforms the saccharine matter in the *must* into alcohol and other products which together form wine, so, in *acetic* fermentation, it would seem that another similar organism transforms the alcohol into acetic acid by depriving it of a portion of hydrogen and substituting for the latter an equivalent quantity of oxygen.[1]

Briefly, in acetic fermentation we have the advent and growth of a ferment known commonly as *vinegar-plant* or *mother of vinegar*, which, placed in contact with sound wine exposed to atmospheric action, causes it to acidify, and eventually transforms it into vinegar.

If wine be placed in casks which have been used to hold vinegar or wine already attacked with acidity, it will infallibly sicken by acetation, and if the malady be allowed to establish itself, the wine may be regarded as lost. But acetation not unfrequently sets in, without actual contact, in wine which is sound but improperly looked after. The germs of ferment are carried by the air and deposited, as in a seed bed, upon the surface of the liquor; finding there all the conditions essential to their development—the organic and mineral elements requisite for their nutriment, free access of air, and a favourable temperature—they grow, like all other forms of vegetation under the influence of a good soil and a suitable climate, and speedily effect the transmutation of the alcohol above described. From what has just been said, it is easy to understand how acetation may set in and spread; still, when the malady makes its appearance in a sound wine, which has neither been in contact with nor in the proximity of vinegar-tainted sources, it does not appear easy at first sight to determine whence the germs of the ferment have proceeded. This question is of importance, not only in a scientific but also in a practical sense, as it enables us to determine the relative importance and influence of the several conditions, to which the wine has been subject, in originating the malady in question.

The advocates of the theory of spontaneous generation maintain that ferments, like other organisms, may originate *de novo* by the mere aggregation of their ultimate atoms under special favouring circumstances. Were this doctrine tenable, we should have scanty hopes of saving wines from the effects of fermentative influences, as the adoption of any preventive measures would presuppose a very profound study of the conditions essential to the generation of the latter, which would be extremely difficult to obtain. Happily, experience does *not* confirm this theory. What it does prove is that these organisms perpetuate their species by propagation, and also, that they are subject to material modifications by the influence of external circumstances.

Another party, holding views directly antagonistic to those of the supporters of spontaneous generation, believe in the existence of a special ferment in each individual form of fermentation, and also, that each species of ferment is propagated by means of its own germs alone. A third party, whom we may designate the "moderates," assume that a ferment may possibly be modified by the conditions to which it is exposed. Thus the alcoholic ferment, which, in its normal state, decomposes sugar and so produces alcohol, may, according to them, under the influence of special circumstances become so far modified that it shall again decompose the alcohol and turn it into vinegar.

Setting aside the first-mentioned theory for want of positive proof, and admitting the second, we must suppose that the germs of acetic ferment exist, like many others, in the air, and that they become intermixed with the wine during the process of manufacture, or on some occasion when it has come in contact with the atmosphere or with the air contained in the casks, that under the influence of suitable meteorological conditions they grow, and by the exercise of their vital functions transmute the alcohol into vinegar. If we adopt the third hypothesis, which involves the possibility of a specific modification of the ferments themselves, we must take for granted that a small portion of alcoholic ferment has remained in the wine after making, which does generally happen, that owing to some transformation or modification of the conditions under which it existed in the *must*, it acts upon the alcohol, and with the aid of the oxygen in the air turns it into acetic acid or vinegar.

In each of the latter hypotheses we have an initial ferment—certain organic and mineral substances serving to nourish it—and a suitable temperature—as conditions essential to the development of that form of fermentative action which results in acetation.

Supposing these views to be correct, if it be possible to exclude the fermentative germs, or to render them inactive, to avoid the access of air and exposure to a temperature suited to fermentation, we have the means of preventing acetation.

The precautions enjoined in the first portion of the present treatise—especially the fermentation of the *must* in *covered* vessels, and repeated racking and clearing at suitable seasons—are designed to secure the separation of the excess of ferment which becomes intermixed with the lees. This separation, generally speaking, is not effected completely, but nevertheless it diminishes the chief exciting cause of acidification. An excess of alcohol in wine arrests fermentative action, as the latter is impossible in a liquor containing over eighteen per cent. of pure alcohol. Regarded from this point of view, the practice of brandying is unquestionably to a certain extent a preventive of acetation; but unfortunately brandying, besides its costliness, has the effect of rendering the wine excessively stimulant, and thus depriving it of its alimentary and restorative properties. Brandy preserves wine as it does fruit steeped in it; but neither the wine nor the fruit have the same alimentary properties after this treatment as before.

The fermentative principle also becomes inactive and loses its vitality when the wine in which it exists is subjected to a temperature above 120° Fahr. or below 21° Fahr. Upon this fact are based certain methods of preserving wines, of which we shall speak in subsequent chapters.

To prevent the access of air is an indispensable condition to the prevention of acetation. For this purpose it is desirable that the casks should be kept carefully filled up, and that wine—those sorts especially which are most subject to acetation—should be protected from contact with the air during the process of racking, as suggested in part i. pp. 95 *et seq.*

Exposure to a temperature suited to acetic fermentation may, to a certain extent, be guarded against by keeping the wine in cool, dry cellars underground; but this method cannot always be pursued—firstly, owing to the want of cellars, which are sometimes difficult to construct in suitable situations; and secondly, because the wine should be able to withstand the changes of temperature to which it must necessarily become exposed in passing into the hands of the consumer. As the rise of temperature in cellars is a not unfrequent cause of acetic fermentation in certain wines, it is desirable that the floors should be sprinkled with water when necessary, and the casks covered with wet cloths, which, by aiding evaporation, contribute materially to the reduction of the temperature.

All the above-described measures are preventives, and, if rigorously followed up, will secure the wine against acidity. But, in practice, it is not always possible to carry them out to the letter; and wine may even contract the malady in question through certain unfavourable contingencies in the vintage or by some other fortuitous circumstances. We have then to consider whether it should be abandoned to its fate or an attempt be made to cure it by interrupting and arresting the progress of the disease.

If the acetation is in an incipient state, it may be possible to arrest it, so that the wine may be consumed without prejudice to the public health; but when the disease has reached a certain stage, this is impracticable. We must secure the residue of the alcohol by distillation, if the acid be not in excess, or devote it to the manufacture of vinegar, if this be possible; for it must be observed that wine in a state of acetation does not always make good vinegar.

To know what course to pursue, we must carefully watch all wine which, from the conditions to which it has been or may be exposed, we have reason to suspect may be deficient in constitutional soundness.

Determined acetation is readily recognized by the presence of a vinegar-like odour and taste. When these symptoms are very strongly marked, the wine is radically spoiled. But before reaching this stage, the wine will betray sure signs that disease has set in, and the least of these should never be neglected, as then is the time for remedies to be applied with a reasonable hope of saving the wine.

Let us now see what are the premonitory symptoms of acetation. Like all other diseases of wine, it is preceded by a more or less marked *turbidity*. When wine, in a state of repose, is not perfectly limpid, we may always suspect it of a disposition to *sicken*. As perfect clearness is an indication of soundness in wine, so persistent turbidity or muddiness is an infallible sign of disease. In casks which are not completely full—and it is in these that acetation most often occurs—a species of crypto-

[1] It must be remembered that both these substances, alcohol and vinegar, are composed of the same elements, carbon, hydrogen, and oxygen, but in different proportions. The initial letters below represent the molecular elements, or, as chemists call them, the equivalents of each:

Alcohol = CCCC · HHHHHH · OO = $C^4 H^6 O^2$
Vinegar = CCCC · HHHH · OOOO = $C^4 H^4 O^4$

Here we see that in the conversion of alcohol into vinegar two molecules of hydrogen will be replaced by two of oxygen.

gamic vegetation known as *flower of wine* (mycoderma vini) often spreads over the surface of slightly or moderately alcoholic wines. This, although not direct evidence of acetation so long as the effloresence is white, is nevertheless a sign that the wine is disposed to acidity under the influence of conditions favourable to the development of acetic ferment. If instead of being white the flowers are of a ruddy colour, they are *flowers of vinegar* (mycoderma aceti). In this case, the upper stratum of the wine, at least, is attacked with acetation. Microscopical investigations are of great assistance in distinguishing these two mycoderms as well as other suspected ferments which may possibly exist amongst the lees of the wine. Unfortunately all are not familiar with this mode of observation, which requires practice and a certain quicksightedness on the part of the observer; for which reason we shall not speak here of its application to the study of wines and their diseases. Another sign of acetation is the appearance of a sort of sticky substance on damp portions of the outside of the casks near to badly-closed seams, because this glutinous matter is always associated with a certain form of acetic ferment. Accompanying it is a troublesome swarm of little gnats, which are always present when wine is acetating. As the acidity increases by the absorption of the oxygen of the air in the cask, the external air seeks to force its way in, and when the bung is raised, a slight hissing noise is audible similar to that produced by the opening of the stop-cock of an air-pump.

Persons who possess a keen sense of smell and a delicate palate can readily detect the first symptoms of acetation, and then is the time to save the wine. In examining the wine, that at top, in contact with the air, should be set aside. If the wine taken from the lower portion of the cask shows like tokens of acidity, the evil is past remedy. When the wine is affected at the top only, the lower portions may be racked off over the fumes of sulphur into a fresh well-sulphurized cask; there should then be added to it a couple of *litres* of good brandy per pipe, and ten or a dozen litres per pipe of well-tasted wine to restore its flavour. This done, it should be clarified with white of egg and allowed to stand until it becomes clear. Lastly, it should be racked off into another cask which has been well washed and sulphurized. To ascertain the depth of the affected portions, the wine must be tested at different depths by means of a spile inserted in the walls of the cask. The upper portion of the wine should then be run off to the level of the first hole at which the wine shows itself perfectly free of taint. This portion should be used for distillation or the manufacture of vinegar, and the remainder treated as above described. By these operations we separate the acid portions of the wine from the remainder, which, though in danger, is still sound. When the fermentation has spread through the whole volume of the wine, so that it shows an appreciable quantity of acetic acid, it is impossible to re-establish the wine without the abstraction of the acid. It is easy to neutralize the acetic acid and to disguise its peculiar characteristics, but the means employed for this purpose greatly affect the taste of the wine, and in many cases are highly injurious to health. Some recommend caustic potash, carbonate of potash, or the neutral tartrate of the same, for the neutralization of the acetic acid: these form an acetate of potash, which becomes dissolved in the wine, imparting to it a very disagreeable taste, and, except in small quantities, a purgative quality. We do not recommend these measures, as, before employing them, it is indispensably necessary to determine the proportion of acid present in the wine, so as to use enough to neutralize it and no more. This, however, may be readily done by persons the least accustomed to chemical manipulation. The employment of carbonate of lime, or of any other metallic base, should be proscribed as a fraudulent practice, involving danger to the public health, and opposed to commercial honesty and good faith. The use of chalk or carbonate of lime is only permissible for the neutralization of the acid in wine intended for distillation, so that the acetic acid, which is volatile, may not pass over with the alcohol.

Persons have not been wanting to advocate the admixture of sound wines with others in which acetation has commenced, on the ground that the acidity is destroyed by the admixture. Never was there more unwise counsel; it is the worst possible advice, as it entails the rapid deterioration of good wine; it stimulates the acetic fermentation, which spreads rapidly, and eventually ruins the whole. Neither must this practice be confounded with that recommended above of mixing a small quantity of good wine with wine that has been separated from its tainted portions after racking. The object in this case is to bring back the bouquet and flavour of the wine, which disappears *before* the manifestation of acetic action.

Many, indeed, are the rules and precepts given in books upon this subject, but few of them can be recommended for adoption. In Greece it is customary to employ resin as a preventive of acetation. This appears to us to impart a disagreeable taste to the wine, which may not perhaps be objectionable to those accustomed to it. Almost all the Greek wines at the Paris Exposition of 1867 showed this defect, which led to their rejection by the jurors. Some of our Alemtejo wines have it also, owing to the custom of pitching the sides of the wine-jars.

Alarte, speaking of the remedies for acidity, says:—"All these remedies I hold to be apocryphal, because wine in making vinegar loseth the heat of its nature and becometh cold and degenerate, nor can it be made again what it once was, because no natural object can pass *de privatione ad habitum;* so wine which hath become vinegar can never again be made wine. If assistance be given before the substance of the wine hath been penetrated, it is possible to apply remedies to preserve it, but after the acid hath formed there is no remedy."

The latter reflection is sound, as chemical synthesis has never yet found a practical mode of changing acetic acid into alcohol.

F. Perreira Rebello da Fonseca, in attempting to explain the acetation of wine by a theory now inadmissible, recommends that when the acetic action is first observed, the wine should be racked off into new and clean casks, which should not be completely filled; these should be rolled about for some time, so that, as he tells us, "repeated compression may recover the elasticity of the fixed air and expel anything atmospheric;" after which he enjoins the addition of a strong dose (*boa porçao*) of brandy. The first portion of this process, involving the supposition that the atmosphere exerts a *mortifying* influence, is entirely opposed to what theory and practice have taught us of the nature and cause of acetation; the agitation of the wine in contact with air can but serve to aggravate the acidity. The addition of a strong dose of brandy appears to have been his favourite and universal specific, a sort of panacea for all the ills to which wine is heir.

P. Rebello, in his day, was one of the most influential growers of the Douro, but in this district acetation is not common, owing to the natural strength of the wines and the methods employed for their conservation. For the Douro wines large additions of brandy are an excellent preservative, but the practice is inapplicable to natural-made wines. It is beyond dispute that a degree of alcoholisation in wines of 18 per cent. is sufficient to destroy all the germs of secondary fermentation; but this is inadmissible with genuine wines of moderate strength such as we desire to see in increased demand.

Vincente Coelho Seabra da Silva Telles gives some excellent rules for the prevention of acetation, as the following:—1st. To prevent exposure of the wine to the air by keeping the casks filled up and well tamped. 2nd. To separate the wine from the lees. 3rd. Clarification—to secure the deposition of the lees. 4th. To keep the wine either in large quantities,[1] or in bottles well corked and sealed. 5th. To keep them in a cool place. 6th. Not to admit the approach of any acid bodies, &c. For this reason Seabra declares against sulphurization, because, according to his view, sulphurous gas is acid, and leads to the formation of sulphuric acid. This argument has not the least weight: both theory and practice are in favour of the use of sulphurous gas. By the combustion of sulphur in casks we get rid of the oxygen, the presence of which is hurtful to wines subject to acetation, and substitute for it sulphurous gas, which is a preventive of fermentation by its paralysing influence on the ferments themselves. To continue, Seabra adds, 7th. To treat the wine well with brandy, as the latter is a preventive of fermentation. These methods, he says, can rarely be all used together; we must employ them as circumstances render expedient, so that our wine may never acidify. Such are the remedies proposed by Seabra, and when they are of no avail, the best thing to be done, he declares, is to sell the wine, or distil it, or turn it into vinegar bodily. The addition of sugar, molasses, and honey with which he proposes, in perfect good faith, to disguise the acidity, are not worth recapitulation. They are prejudicial because they aggravate the evil; and they are incompatible with commercial probity, as they tend to mislead the consumer.

The Viscount de Villarinho de S. Romao contents himself with the repetition of that portion of P. Rebello's advice recommending the addition of brandy, after racking into a fresh cask, as a means of arresting the progress of acetic fermentation.

To recapitulate, it is easier, more reasonable, and more advantageous to prevent acetation than to attempt to cure it after it has set in. For this end we need scrupulous cleanliness, both in the manufacture and keeping of wine, and the prevention of contact with the air during fermentation and afterwards in the

[1] This recommendation to keep wine in large quantities is of no practical utility. It has no effect on the wine. In the great wine countries, like Médoc, Burgundy, &c., the wine is kept in casks holding 228 *litres* each (about 50 gallons English).

cask, which latter should always be kept well filled up and carefully tamped.

To prevent the spread of acetation we must separate the sound from the affected portion of the wine as we would sever a gangrenous member to save the rest of the body. In a subsequent chapter we shall give some instructions for the application of heat as a means of arresting incipient acetation.

In conclusion, we may observe, that should the disease have been unwisely permitted to get so far ahead as to render the above means inapplicable, our only resource is to make what we can out of the wine according to circumstances, either by distillation or by converting it into vinegar, which, as we have said, is not always easy.

### 15.—Turning or Rising.

Although Portugal has long been esteemed one of the foremost wine-producing countries in Europe, it must be confessed that our œnological phraseology is in a very vague, confused, and anarchical state. An illustration in point is afforded by the difficulty of finding any single word to denote the form of disease in wine to the consideration of which the present chapter is devoted.

It frequently happens that wine, after keeping good for some time, will turn thick and show symptoms of some internal change accompanied by a certain effervescence produced by the evolution of small bubbles of gas. In closed casks these accumulate, and exert a sensible amount of pressure, by which the wine is driven into the joints of the staves, and, unless the bung be removed, is ejected through the orifices thus formed, as under the influence of some violent internal impulse.

If the wine be retained in the mouth in tasting, the existence of fermentative action is revealed by a sickly taste which is popularly designated *choco* (addled).

If the wine be exposed to the air and stirred up its turbidity increases, it becomes darkened in colour, and opaque.

Unless treated in time, this affection ruins the wine and ends in its putrescence—the latter not being a disease, but the ultimate decomposition of the dead wine.

French œnologists recognize the malady under the name of *pousse*, *poux*, and *tour*, and wine so affected they describe as *poussé*, *tourné*, *monté*, and by a score of other appellations, their œnological nomenclature being as devoid of rule as our own.

Amongst old Portuguese writers, we find Alarte speaking of wines which have "worked" (*vinhos refervidos*), and wines which "turn" (*se toldam*), without describing these affections. José Verissimo Alvares da Silva, treating of the diseases of wine, alludes to some which "turn" without becoming either acid or greasy. Pereira Rebello distinctly mentions "turned wine," and adds that the disease is very common in Minho where wine so affected is said to be *lotado* (marked).

Seabra speaks very briefly of *vinho toldado*, without describing precisely the nature of this species of affection.

The Viscount de Villarinho de S. Romão never mentions it clearly, and in opposition to the assertion of Pereira Rebello, employs the term *lotado* as synonymous with *gordo* (a word usually applied to wine which has become "ropy"); he also alludes to the disease in question under the name of *podridão* (putrescence).

M. Ferreira Lapa designates wines affected as above described under the names of *vinhos toldados*, *lotados* and *voltados*. Lastly, in the Douro, the term *desprezo* is applied to a particular form of affection which shows itself occasionally in good wine, that has been improperly kept, by a certain softness and a taste of the lees combined with a slight but marked acidity. This we are disposed to think is an affection of the same class, modified in its symptoms by the nature of the wine in which it makes its appearance.

We propose to describe the morbid affection by the influence of which the lees rise, and the wine becomes thick and "turns," as it is commonly called, under the names of *turvaçl'o* and *volta* (turning and rising).

Turning or rising, in point of fact, is an internal and abnormal change which shows itself in the lower portion of the liquor, or, to speak more correctly, in the sediment thrown down by the latter—in contradistinction to acetation, which generally sets in at the top where the wine is in contact with the air—and spreads by slow degrees, destroying the limpidity of the wine, altering its taste and smell, and leading, ultimately, to its utter and complete disorganization. Long as this disease has been recognized by scientific and practical men, it must be admitted that our knowledge of it, of its causes, and of the remedies most proper to counteract their effects, is still very imperfect.

Some œnologists seek to explain this peculiar form of disease in question, by chemical considerations. Amongst these, Batillat attributes it to the transformation of a portion of the tartaric acid into malic acid at the expense of the other constituents of the wine, but, as his theory is not based upon a rigorous analysis, it is inadmissible.

It is possible and indeed probable that different causes may produce "turning," and, consequently, that there may be different forms of the disease, still, that which appears to be most common, and which affects wine in bad seasons, or when made of inferior fruit grown in low damp situations, or wine which has been improperly treated, especially in those cases where facilities for "racking" and the separation of the wine from the lees have been wanting, is an affection produced by a particular species of ferment existing in the last mentioned deposit, which, under various circumstances—as in hot weather, during thunderstorms, at the seasons of the budding and flowering of the vines and the colouring of the grapes before vintage—rises, and produces fermentation in the wine.[1] Extremely alcoholic or liqueur wines, or those which are perfectly clear and free from sediment, and so are exempt from the presence of ferments and their attendant evil consequences, never "turn" or "rise."

The Viscount de Vergnette, in his excellent Treatise on Wine, recognizes *two* species of turning, which he describes separately in chapters xxi. and xxiii. In regard to the first, which he designates *maladie du tour*, he says:—"This disease, or rather this peculiar condition of wine, is observable even in the vats. The wine ferments badly and undergoes a change both in taste and colour. It is deficient in clearness, has a characteristic yellowish look with a nauseous and bitter taste; on exposure to the air it becomes opaque and presents altogether a peculiar and repellent appearance. When wine in this state is subjected to analysis, strange to say, it proves to be rich in alcohol and with a very small proportion of free acids."

This disease, or peculiar and defective state of wine, which the illustrious Burgundian œnologist describes under the name of *tour*, differs considerably from that subsequently described by him in his twenty-third chapter under the designation of *pousse*. The latter, which is "turning" properly so called, shows itself at a later stage, in spring time, by the rising of the lees followed by a perceptible fermentative action evidently caused by the evolution of carbonic acid. The former happens when the quality of the wine has been impaired by the bad condition of the fruit, and appears at an earlier period.

M. de Vergnette observes: "It occurs in cold wet seasons, generally at the moment of vinification, and when the grapes have been injured by the wet or decomposed by mould."

With grapes that are mouldy, decayed, bruised, or withered, even if used in small number, we can never hope to make *good* wine. As these injuries are for the most part external, the grapes so affected should not be placed in the tanks or vats, nor trodden out, but should be *expressed* apart, and the *must* run off from them made into a white wine, which will be sound enough to be drank without inconvenience. The wines which "turn" at the early stage to which M. de Vergnette refers when treating of the form of disease he designates *maladie du tour*, are red Burgundies, and in these the chief seat of the malady is the colouring matter. In the small quantity of sediment which they throw down, no particular form of ferment has been detected. We have ourselves this year had an opportunity of seeing a white wine from the Horta da Villariça in an analogous condition. This wine had fermented badly, and in November, when all the others were more or less clear, was still in a thick and turbid state; when exposed to the air it darkened, and assumed a very disagreeable appearance; the taste was less affected, and retained a certain sweetness. Its alcoholic strength in this state was 11·5 per cent. of pure alcohol, its acidity was equivalent to 0·470 per cent., and its specific gravity equal to 1·020. Under the microscope the sediment only showed a few globules of alcoholic ferment, some crystals of tartar, and a good deal of amorphous fibrine. After clearing with white gelatine, which caused a profuse deposit, the wine improved, and without further treatment assumed a very satisfactory condition in regard to colour and flavour. This turbidity, which shows itself in the making, and remains when the wine should be clear, must not be confounded with the disease called "turning," which sets in at a later stage, and is due to fermentative action.

It is possible, and even probable, that wines thus affected have received the germs of the malady from mouldy or blighted grapes, which, through neglect or inadvertence have found their way, even in very small numbers, into the vats or tanks.

The microscopical researches of M. Pasteur tend to prove that the change in "turned" wine is caused by a particular ferment, a species of mycoderm, which appears in the form of fila-

[1] This coincidence of the movements in the wine with certain periods of vegetation in the vine, need not be regarded as implying any occult relationship betwixt the wine and the plant, but may be explained by the effect of certain meteorological influences peculiar to those seasons on the growth of the ferment.

ments of extreme tenuity, closely resembling those of lactic ferment, under the influence of which lactic acid is produced. Nevertheless M. Pasteur recognizes marked differences between the filamentary forms in lactic ferment and those which he assumes to be the causes of "turning" in wine. The Viscount de Vergnette denies the existence of any peculiar form of ferment in the sediment of wines that have sickened with this disease. According to his views these filaments are the vestiges of vegetable substances or fibrous matters which may be found in the sediment of every wine. The disagreeable taste in "turned" wine he attributes to a change in the colouring matter of the grapes, caused by blight or decay.

The fact is, that the disease has not been as yet adequately studied. If there be a particular ferment in the case, as the evolution of carbonic acid gas would lead us to infer, we know nothing of the other products, which characterize it, in the way alcohol and certain other matters characterize the alcoholic and acetic acid the acetic forms of fermentation.

"Turning" is never instantaneous in its effects: it has a beginning, a more or less protracted continuance, and a fatal termination. M. H. Marchard, who has written extensively on the subject of this malady of wine, recognizes *three* degrees of severity—three distinct phases of the disease, each requiring a different mode of treatment.

The first phase is when the wine is thick, but has no perceptible effervescence, and does not become darkened on exposure to the air. If we trace this affection to its origin, we shall find that it begins in the lower portions of the liquor, and gradually spreads in an upward direction, in contradistinction to acetation, which begins at the top, where the liquor is in contact with the air, and extends downwards. The sediment of wine in this state shows the filamentary forms that, according to M. Pasteur, are characteristic of the specific ferment to which he assigns the cause of the disease.

Wine showing these primary symptoms may be cured by "racking" and other suitable measures applied in time. M. Marchard recommends the following process:—Take a cask of such dimensions that it may be completely filled by the sick wine when the latter has been cleared and is free of lees; burn some brimstone in it, with all due precautions against particles of ash or unburned sulphur falling into the cask; pour into it a certain quantity of good brandy, in the proportion of one *litre* of brandy to five *hectolitres* of the wine; then fill up with the latter. Clear with white of egg, allowing sixteen eggs to the pipe, and when the wine is clear, rack off into a clean cask lightly sulphurized. Wine well "cleared" in this manner, and kept in a cool place, will recover itself completely, and resist fresh inroads of the disease.

In a future chapter we shall speak of the application of heat as a remedy for this as for all other forms of disease in wine.

The second phase of "turning" commences with a slight effervescent action, which can be detected when a draught of the wine is retained for some time in the mouth. At this stage it becomes clouded on exposure to the atmosphere. Henceforward the wine "rises," and the fermentative action becomes general. This affection is serious, and difficult to deal with.

The third phase shows itself by violent fermentation, a brisk effervescence which is observable in tasting, and a disagreeable flavour: the wine darkens rapidly on exposure to the air: the affection becomes general, and the "turning" is complete.

It appears to us that the only practicable course when wine is thus affected is to devote it to purposes of distillation. It still retains its alcoholic strength, but the brandy manufactured from it will be defective, unless the taste of the wine, which clings to it, be removed by the use of charcoal. The violent mode of treatment prescribed by M. Marchard for wines in the two last phases of "turning" may, however, be tried.

"In such a case," he says, "the sick wine must be repassed through the *balsa*—or 'put in purgatory,' as it is called in some wine-growing localities—and the best results may be anticipated so long as the *balsa* itself is fresh.[1]

"The quantity of the latter must be proportionate to the volume of wine needing restoration. If we attempt to pass a considerable volume of wine through a small quantity of *balsa* we spoil the latter without curing the wine.

"If the quantity of *balsa* available be small, we should increase its potency by the addition of fresh grapes.

"The repassing of 'turned' wine through the *balsa* is no doubt a convenient and efficacious mode of remedy; and if the operation be carefully performed and the *balsa* for it sufficient in quantity, the liquor recovers its winey taste and colour, and loses the disagreeable pungent flavour characteristic of turned wine; results not attainable by any other method."

[1] *Balsa*—the solid portion of the *must*; the *chapeau* of the French.

M. Marchard then adds some useful directions, from which we transcribe the following:—

"Always use fresh *balsa*, which has not been made longer than twelve or fifteen days at most.

"To each hectolitre of the sick wine allow a quantity of *balsa* sufficient to furnish 3 hectolitres of wine.

"Pour the affected wine over one portion of the *balsa;* let it stand twenty-four hours, and rack off.

"Pour the same liquor over a second portion of the *balsa;* let it stand three days, and rack off.

"Pour it again over the remainder of the *balsa;* let it stand for a fortnight or three weeks, and rack off.

"The liquor remaining in the *balsa* which retains the taste of the tainted wine must not be mixed with the rest, but must be expressed and set aside for distillation."

The whole process appears designed to remove the ill-taste and restore the colour of the affected wine at the cost of the fresh and sound *balsa*, but we believe it to be inadequate to remove or destroy the cause of the malady. The *balsas* used in the preparation of the *tannic alcohol*, spoken of in sec. 10, p. 376, should be far more efficacious for this purpose, especially if followed up with a good "clearing" with isinglass. These *balsas* contain the alcohols, the colouring material, with the sapid matters and tannic acid, necessary to the reconstruction of the wine.

M. Marchard's process requires fresh *balsa*, which is not always obtainable out of the vintage season: at any other period we can only have it ready for use by pursuing the method adopted by M. Barral.

Some writers attribute "turning" to the decomposition of the bi-tartrate of potash, and recommend the use of tartaric acid in a proportion to be determined experimentally, as Batillat suggests, by dissolving 40 or 50 grammes of the tartrate in a hectolitre of the wine, and increasing the dose until the desired effect is produced. During the first stage of the malady the addition of small quantities of tartaric acid combined with "brandying," racking off into well-sulphurized casks, and energetic "clearing," will no doubt aid in the cure, but when the "turning" has got further ahead, the amount of tartaric acid required, as Batillat himself admits, would render the wine undrinkable.

Amongst the remedies indicated by Alarte, is one in accordance with the method above prescribed for the first stage of the malady. He says:—"Sometimes wine *bota* (casts up) and changes colour, which usually follows on a bad vintage. When the wine is much affected in this way it is hard to cure: it is customary, and I have never found the treatment fail, to rack it off, and sulphurize and clear it. But the best course is to try and sell it, for the more it becomes affected the more it loses its flavour."

J. Verissimo Alvares da Silva simply prescribes the "clearing" of "*vinhos toldados*" in the ordinary manner. Pereira Rebello recommends brandying and the addition of molasses. We have no hesitation in counselling growers to abstain from the latter practice. Seabra, in the memoir above referred to, recommends the treatment of "turned" wine by the usual methods of "clearing."

From all that has been said, it will be seen, that the "turning" of wine is a malady very imperfectly understood, alike in regard to its proximate causes and its ulterior effects. In its early stage the most advisable mode of treatment is racking off into well sulphurized casks, following up with "brandying" and "clearing." In the more advanced stages, when the wine "works," and acquires a bad taste and odour, the disease may be said to be incurable. It may be used for distillation, but with a risk of getting bad brandy. As in the case of every other morbid affection to which wines are subject, it is wiser to anticipate and prevent the appearance of the disease than to leave the wine at the mercy of the many sinister influences that compass its destruction.

### 16.—Bitterness.

Betwixt the form of disease known as "bitterness," and the "turning or rising" spoken of in the preceding chapter, there appears to subsist, as we shall presently see, a very close relationship. For this reason, it has been thought expedient to treat of these maladies consecutively.

Amongst Portuguese œnological writers, M. Ferreira Lapa alone makes mention of the particular form of disease that causes "bitterness" in wine. He reproduces what has been said upon the subject by M. Maumené, in his work entitled "Indications théorétiques et pratiques sur le travail des vins," combining therewith M. Pasteur's description of a series of microscopical researches into particular forms of mycoderms, which, in the opinion of that distinguished œnologist, are the true cause of the malady. Are we to attribute the existence of this *hiatus* in Portuguese œnology to the chance immunity

which our wines have hitherto enjoyed from this variety of disease? It is possible.

Still, we have heard growers assert that they have met more than once with a case; and we ourselves, as we shall hereafter describe, once observed an instance of a wine evidently affected in this manner at the quinta of Madureira, in Villares de Villariça. Whether the latter was or was not the result of real disease or organic change in the wine, it appears to us that our wines —so varied in character and so little studied as they are—can scarcely claim to be, alone of all others, exempt from this malady. Consequently we have thought it desirable to give, briefly and concisely, as suited to the limits of this little treatise, the opinions on the subject of "bitterness" advanced by those writers whose views are entitled to most weight.

The best red Burgundies—made from a variety of grapes which the French call *pinots*—are most subject to this affection. This variety, in our opinion, belongs to the class, known amongst us under the names of *tinta de França*, *tinta franceza*, or *tinta francisca*, which is common in Douro. For this reason we have deemed it advisable to describe the malady, although the Douro wines are not affected by it, owing to the excessive fortifying they receive.

The particulars here given have accordingly been taken from the works of Burgundian œnologists. The Viscount de Vergnette distinguishes two kinds of bitterness—the first affects the wine in its second or third year, the other is only found in very old wine in bottle. The latter is far less serious in its effects, and is chiefly remarkable from the circumstance of its appearing only in old wine which has remained bottled for years in good condition: for this reason, it is termed by some people the *taste of age*. The former is far graver in its consequences. It attacks wine in the first years of its existence while yet in the wood—affects it profoundly, and eventually destroys it. M. de Vergnette describes it thus:—"At first the wine has an odour *sui generis*, its colour falls off, and a nauseous taste is perceptible. Wine-coopers speak of wine thus affected as *doucina* (cranky). The bitterness has not shown itself at this stage; but its advent is sure unless proper measures be taken to prevent it. All these symptoms become rapidly aggravated: the wine deteriorates and gets bitter, with a slight show of fermentation caused by the presence of some vestiges of carbonic acid. As the disease progresses still further, the colour changes, the tartar is decomposed, and the wine becomes unfit to drink."

He adds:—"It does not require that the symptoms of disease should have advanced to an extreme to affect the value of the wine. A mere change of smell, let the liquor be ever so sound, will cause wine worth 500 francs the barrel (228 litres) to sell at 100 francs, and a bottle of *romané*, which should fetch 15 francs, to go for 1 franc."

In Burgundy, this malady sometimes acquires the proportions of a veritable calamity. The evil never appears in isolated cases here and there, but attacks large quantities of some particular crop at one fell swoop, as occurred with the wines of 1840 and 1842; so that, as in those years, the consequences are felt far and wide.

The fact that certain vintages are more prone to spoil than others, should direct the attention of growers to the conditions, individual as well as general, under which the operations of gathering and making are conducted, and awaken them to a sense of the importance of registering all facts which exert an influence over the constitution of the wine. These registers should show, at the least, the following details:—1. Weather-record, before and during vintage and vinification, noting all important changes from day to day. 2. Record of condition of fruit when gathered. 3. Diary of manufacture, recording commencement and termination of fermentation, temperature at which it set in, &c. 4. Tests of the *must*, to show, at least, density, degree of sweetness, and acidity. 5. Alcoholic tests of wine in wood. 6. Dates of racking, clearing, and other operations, and memoranda of the modes in which they were effected.

In case disease should show itself, a register of this kind would be of great assistance in investigating the cause and forming conclusions respecting the most advisable modes of treating it. Indeed, were it not for the records which have been kept in various countries by a few far-sighted growers, we should be sadly at a loss for materials to enable us to pursue the study of the diseases of wines. By some this practice has been carried out unceasingly, and amongst others, by M. de Vergnette, who asserts upon the authority of his observations so recorded, that "bitterness" never shows itself in Burgundy wines made from good vintages; that it is only in cases where the grapes have been deteriorated, as they were by the blights of 1840 and the rains of 1842, that the disease appears.

Here we have a similarity between "bitterness" and "turning." The bad condition of the fruit—rotten, mouldy, or spoiled by the weather—renders the wine weak and liable to turn: the same circumstances leads to bitterness in finer wines. "Turning" is a malady of ordinary wines—"bitterness" of fine wines. Possibly, both are results of one and the same cause, acting in different ways.

The "bitterness" which showed itself in the Burgundies of 1861, was thus connected with the marked continuance of bad weather. To a very hot and dry summer succeeded a rainy autumn, during which some vintages were abandoned on account of the wet weather.

M. de Vergnette states that he has found that high-coloured wines, rich in extractive matters, are more subject to turn bitter than others. He says that in the first stage of the malady neither the alcohol, nor the tartar, nor the extractive matter, appears to suffer, only the colour changes perceptibly. And here it should be noted that *white* Burgundies *never* turn bitter. It will be presently seen that the only case of "bitterness" which has come under our personal notice was that of a white wine, but it should be observed that this wine had been made by a process similar to that adopted in the manufacture of red wines, and totally different to the mode in use with the rich and costly wines of Montrachet and Meursant, described in the writer's report on the Exposition of 1867, p. 55. The distinguished Burgundian œnologist appears to think that bitterness is the result of a change in the colouring matter caused by the action of oxygen; but the facts, or rather the sole experiment upon which this hypothesis is based, cannot be regarded as conclusive. The experiment in question consisted in the separation of the pulp from the skins of the grapes, which were then washed in cold water and digested in alcohol. An alcoholic solution was thus obtained of the colouring matter which is resident in the skin of the fruit, like the sweetening principle. This solution, which was of a beautiful ruby red, on exposure to a diffused light, became speedily changed, leaving the alcohol of a pale sherry colour, and depositing in the bottom of the flask, in which it was, a light grey precipitate, with a bitter flavour derived from the colouring matter. Hence he concludes that the bitterness in the wine arises from an oxidation of its colouring matter under the influence of light, and he suggests as preventive measures the sulphurization of the casks in racking, and the protection of the wine from the light. It is obvious that the conditions of the foregoing experiment differed widely from those to which wine is subject within a wooden cask, where light cannot enter and air only in exceptional cases. In fact, he admits that there must be something else at work in the production of the morbid phenomenon, and this something he seeks to explain by the probable influence of a ferment, in which respect his hypothesis approximates to that of M. Pasteur.

M. Pasteur attributes "bitterness," like all forms of disease in wine, to the vital action of a parasitic growth, a particular species of mycoderm, whose existence was revealed to him in the course of his microscopical researches. This is an organic ferment showing itself in the shape of long filaments similar to those observable in wine which has "turned," or is about "to turn," but with their articulations, so to call them, more strongly marked. In both varieties of bitterness, in new wine as well as in old, M. Pasteur detected the same parasite, the only difference in appearance being traceable to the incrustation of the colouring matter upon the filaments found in the sediment of old wine thus affected. He agrees with other œnologists who have treated of this malady, that "bitterness" only shows itself in fine wine—that is to say, in the *pinot* of Burgundy, and very rarely in the *gamai* of the same district. Fine wines, as we have said, are subject to "bitterness"—ordinary wines "turn." The parasitic growths which accompany these diseases both present themselves in the form of filaments, which are bigger and more strongly articulated in cases of "bitterness" than in "turning," in which they are extremely attenuated. Are they one and the same organism developed under different conditions? The question has not yet been sufficiently studied for an answer to be given.

M. Pasteur has also observed another description of bitterness, which is found in wine kept in casks imperfectly filled. This bitterness he attributes to atmospheric action—that is to say, it depends on chemical action, and is not connected with the appearance of any form of cryptogamic vegetation. This kind of bitterness he asserts may be cured by filling up the casks, or by keeping the wine some time in well-filled bottles.

Is this the particular form of bitterness which M. Maumené ascribes to the formation, through the agency of oxygen, of a grey, resinous anhydrate of ammonia? It appears extremely probable. The ferment or the albumenized matter in imperfectly filled casks would supply the ammonia, and at the same time atmospheric action, by promoting acetation, would change the alcohol of the wine into an anhydrate before converting it into acetic acid. According to Liebig's showing, ammonia and this anhydrate combine under the influence of oxygen, into a grey

resinous substance, with a bitter taste. Fumigation with sulphur breaks up this combination by the agency of the sulphurous acid. Consequently, sulphurization and due attention in keeping the casks properly filled up, are the most effectual remedies for this description of bitterness.

In regard to the bitterness which sometimes manifests itself in bottled wine, M. de Vergnette is opposed in his views to M. Pasteur, maintaining that it is essentially different from the bitterness of *new* wine, and denying that it is caused by the articulated filaments aforesaid, upon the ground that a microscopical investigation of the sediment of wines so affected have never shown these filaments to be present in sufficient number to justify us in attributing the affection to their agency. In this case we have a simple alteration of taste resulting from age, which cannot be placed in the same category with the form of malady observable in *new* wine.

Of "bitterness," as of other maladies above described, it may be said, that our knowledge of its origin and nature is still very imperfect; and that, in every case, prevention is far easier than cure.

The processes of "heating" and "refrigeration," of which we shall presently speak, are certainly better adapted to obviate its occurrence than to stay its progress when once it has appeared.

Here we will mention a mode of treatment suggested by M. H. C. Marchard, which may prove serviceable during the earlier stages of the malady. It consists of "clearing," "sulphurization," and admixture with wine of the same description, but of sounder constitution.

In the first instance, "clearing" is performed with white of eggs; the wine is then racked off over the fumes of brimstone into a well-sulphurized cask, until the latter is about three parts full; lastly, this cask is filled with sound wine of the same kind, or with an older wine.

We cannot conclude this chapter without adverting briefly to a case resembling the affection just described, which the writer had an opportunity of observing, although but imperfectly. It was a white wine, of the vintage of 1865, grown and made at the quinta of Madureira, in Villares de Villariça. It had not yet been brandied when we tasted it in May of the succeeding year, and was standing in a large tun of chestnut-wood. It had a rather deep topaz colour, was tolerably clear, brisk and dry, but left a marked taste of quinine on the palate. Its alcoholic strength was 15·7 per cent. of pure alcohol; it contained 2·25 grammes of sugar per litre, and after evaporation gave a residue of 30 grammes per litre. The bitterness was very marked in the extract, and the bitter principle was soluble in water. The sediment could not be submitted to the microscope, as there was none in the bottle sent to the writer. The remainder of the wine was cleared with a small quantity of gelatine, put in a fresh bottle, filled up with good sound wine from the same locality, and allowed to stand for over twenty months. At the end of this time the colour has become lighter, the bitter taste had disappeared, giving place to a very decided "dryness," such as we find in very old wine. At the bottom of the bottle was a very small quantity of sediment, levaceous, and of a grey colour. Under the microscope the deposit showed a few dark dust-like amorphous particles, some crystals of tartar, and some filaments of elongated and articulated form, such as M. Pasteur describes as peculiar to wines affected with bitterness, but very few in number, and without any ramifications. We do not therefore feel justified in pronouncing whether the case in question was or was not an instance of one of the forms of bitterness. Of this affection, as we have before said, there are at least *three* kinds:—1st. The bitterness of new wines, which is common in the finer sorts, such as those made of the *pinots* of Burgundy, and which has some affinity to turning, being, like the latter, the result of secondary fermentation. 2. The bitterness of old wines of the same class. 3. Bitterness produced by atmospheric action on wine kept in imperfectly-filled casks, either directly on the colouring matter, or by the transformation of the ammoniacal anhydrate into a grey opaque resin. In certain cases bitterness may be the result of the chance solution of some bitter principle in the wood of the cask. This was not the case with the wine above referred to, as we were informed that the cask had long been in use, and this effect had never been observed with other wines kept in it. The imperfect observation of a single fact is, however, insufficient for the establishment of a theory. We must wait for fresh data.

### 17.—Mucous Fermentation or Ropiness.

The mucous fermentation of wine, which M. Maumené calls *zymeosis*, is a morbid condition of the liquor more often observable in white wines of a weak, lymphatic constitution than in others fermented in contact with the *balsa*, like the red wines of Portugal, which are always made in this way. The affection is, and should be, uncommon in Portuguese wines, as, generally speaking, both the white and red sorts are fermented in contact with the solid matter. Nevertheless, old Portuguese writers make mention of it; and Alarte records a case of cure, which had been communicated to him, showing at least that the malady was known in his time.

In mucous fermentation, the wine turns thick and mucilaginous, with a certain greasy, oily texture; like oils and syrups it has a tendency to run "ropy," without the noise usually observable in watery fluids when poured from a height; the taste is insipid and nauseating, but the alcoholic strength remains unimpaired; oftentimes the wine recovers itself spontaneously under the influence of cold, or even of mere agitation of its volume.

The opinions of our older œnologists respecting the causes of this affection of wine are unworthy of repetition. They are vague and confused, without exception. Alarte attributes it to *excess of heat*, others content themselves with refuting the erroneous belief that the malady originated in over-ripeness of the fruit. Seabra is most explicit upon this point. He says: "The causes of this malady are neither over-ripeness of the fruit—seeing that the wines of Hungary and Setubal are never so affected—nor a disintegration of its oleaginous constituents, as, 1st, we have instances of wine being thus affected in summer and recovering itself in winter, in which case, what is the agent at work in restoring the union of its constituents?" In this strain he continues, and we may be excused from following him. Further on, he says: "If we consider that, 1st, wines made as we have directed never turn 'ropy'; 2nd, the malady shows itself in wine made of mixed grapes, from which the unsound ones have not been separated; 3rd, different varieties of grapes do not all ferment with equal rapidity—the unripe take longer than the over-ripe, while the mouldy ones speedily pass into a state of putrefactive fermentation; 4th, ropiness sets in during the hottest season; 5th, the lees and tartar are found in considerable quantities mixed with acid floating in the wine; 6th, the wine thus affected never really recovers itself altogether, but retains a peculiar taste, partaking chiefly of acidity; if, I say, we consider all these points, we shall be led to believe in the probability of ropiness *being a result of fermentative action of a mixed character, promoted by heat, and partaking of the vinous, acetic and putrid forms of fermentation.* This theory of the co-existence of these forms of fermentative action is not in any way a necessary consequence of the considerations advanced by the author, nor, were it even proved to be so, would it account for the phenomena observable in mucous fermentation; still the suggestion that the disease was a result of fermentative action was a step in the right direction.

The Viscount de Villarinho de San Romão attributes ropiness to incomplete fermentation resulting from admixture of the grapes, but he is not very clear in the explanation of his views on the subject.

In combating the idea referred to above, that ropiness arises from over-ripeness of the fruit, he mentions a fact deserving notice, to wit, that in the year 1805, he saw wine affected in this manner, which had been made from fruit containing an admixture of sun-dried grapes, that is to say, of grapes withered by the sun before ripening. Count Odart, who occupies a distinguished position in France as a viticultor and a ampelographer, holds that ropiness is a consequence of superabundant fertility in the vine produced by over-manuring, or by some peculiarity in the soil or in the stock. Although the assertion is insufficient in itself to explain the phenomena of the disease, it is in accordance with the observed fact, that thin, weak, watery wines are liable to turn ropy under the influence of the conditions which he describes as conducive to the appearance of the malady.

The famous Chaptal refers the form of vinous degeneration in question to the predominance of gluten or nitrogenous matter in poor, weak wines. Although the theory of this distinguished chemist does not fully satisfy all the requirements of modern science, certain paragraphs of his work, "Essai sur les Vins," may be advantageously transcribed here, as the subject is there treated with great plainness and with all the care and minuteness of a skilled observer.

"Ropiness" (*la graisse*), he says, "is an affection often noticed in wine, in which it loses its natural fluidity and becomes streaky and of an oily consistency. It is known by various names—greasiness, ropiness, &c.

"Weak wines are thus affected.

"Thin wines which have not been much fermented are most liable to it. Thin wine, fermented apart from the *balsa*, is subject to it.

"Wine will become affected in this manner in well-corked bottles. This has been clearly proved in champagne, where a whole crop in bottle is sometimes affected thus.

"Ropy wines, when distilled, yield only a very small quantity of thick, high-coloured, oily spirit."

Chaptal then explains the mode of treatment which he considers best adapted to the treatment of this malady, of which we shall speak in the proper place. He continues: "It is evident, alike from the causes which determine the ropiness of wine,[1] the phenomena observable in wine thus affected, and the modes of cure, that the malady originates in the insufficient decomposition of the extractive principle.

The extractive principle here referred to is the nitrogenous matter which nourishes and supports the growth of ferments; in this respect Mr. Chaptal's theory is in accordance with the views of the majority of modern œnologists.

Amongst the latter we may name M. Maumené, whose opinion carries great weight, on account—not only of his general attainments as a chemist, but in this instance more particularly—of the special attention which he has devoted to the œnology of Champagne, where the wine is very frequently affected in this manner.

M. Maumené, M. François, and other writers, attribute the malady to the influence of glyadine or glutine, a nitrogenous substance, soluble in alcohol, which is found in grape-juice. It is a promoter of fermentative action, and not unfrequently is met with in wine after secondary fermentation, not having been decomposed during the latter process owing to its excess in proportion to the sugar present, or to its not having been precipitated through a deficiency of tannin, which often is present in very small quantities in certain wines, such as *white* wine fermented apart from the solid portions of the fruit.

M. Maumené observes that *zymeosis*, or ropiness, is only produced under certain conditions which he confesses himself to be unable to define precisely, but which depend upon a deficiency of alcohol in the wine, and the hydration of the gluten thus rendered possible.

This, he admits, is mere hypothesis, and very far removed from positive demonstration, but it is strengthened by the fact that tannin, which precipitates the gluten, is used as a remedy, or rather, it should be said, as a preventive, in cases of *zymeosis*.

M. Pasteur attributes the affection to a particular mycoderm, which presents the appearance of strings of bead-like globules destitute of the articulations observed in those found in the lees of wine affected with "bitterness."

Describing the results, as they appeared to him, of his microscopical investigations, he says:—"In conclusion, ropiness in wine is not caused, as it frequently is assumed to be, by the precipitation, under the influence of certain unknown causes, of a glutinous substance having more or less analogy to the gluten of wheat. It is the result of fermentative action caused by the growth of a parasite, the germ of which exists in the fruit, probably in some of the seeds of the grapes, which seeds have become decayed while the fruit was on the stalk, through the agency of the parasite itself, or of some one of its varieties or metamorphoses."

M. de Vergnette, while he concurs with all other œnologists in regarding "ropiness" as an affection peculiar to *white* wines, yet cites a case, which came under his notice in 1845, of a late-made wine of black grapes, very imperfectly matured, from a vineyard which had been touched by the frost in May, and which during fermentation in the vats showed all the symptoms of ropiness. But this individual instance does not invalidate the general rule that ropiness is a species of degeneration peculiar to *white* wines, and more particularly to those which have been made from inferior fruit in a hurried manner, and, consequently, are deficient in the tannin requisite for their conservation.

White wines of a higher class, rich in saccharine matter, well made and fermented, never turn greasy. Immature grapes, in a bad season, never ferment well, and yield a wine, which, even in winter, is devoid of winey sweetness as well as of astringency, and in summer is peculiarly liable to ropiness. It is certain that the latter is a degeneration induced by a particular form of ferment, and that it is favoured by the presence of an excess of nitrogenous matter held in solution in the wine. The phenomenon of running into strings or threads like oil gives countenance to M. Pasteur's theory, which refers it to the presence of large numbers of parasitic filaments floating in the liquor.

Upon one point—the mode of treatment best suited to the prevention or the cure of this disease—the majority of œnologists are agreed. There is an old and a new method. Both should be known, for each is susceptible of useful application. Agitation of the wine in contact with the air and the addition of brandy were the old fashioned modes of treatment, followed in every case by clearing with white of egg or glue. Modern practice includes the employment of tannin or of an alcoholic solution of the tannin contained in grape stones, and "heating," by which the wine is raised to a certain moderate heat by a process of which we shall speak hereafter, and which M. Pasteur regards as a universal specific for the diseases to which wine is subject.

Alarte recommends that the sick wine should be beaten with sacks, and afterwards cleared with white of egg. This is an example of the agitation above referred to. Verissimo da Silva advises the stirring of the wine, racking, and clearing. Similar directions are given in Seabra's memoir, and in the treatise of the Viscount de Villarinho de San Romão. Chaptal tells us that the disease may be cured in various ways:—1st. By exposing the contents of the bottles to the air in a well-ventilated cellarage. 2nd. By shaking the bottles for a quarter of an hour, and then uncorking to permit the escape of the confined air and froth. 3rd. Clearing the wine with a mixture of isinglass and white of eggs. 4th. Putting one or two drops of lime-juice or some other acid in each bottle. With all due respect to the opinions of the illustrious chemist, the last-mentioned remedy appears to us somewhat questionable. M. Machard, an eminently practical œnologist, recommends, as one of the best preventives of ropiness, the practice of fermenting all wine subject to this affection in contact with the husks and stalks of the fruit. When this precaution has not been observed, and symptoms of the malady show themselves, he recommends a mode of treatment, the principle of which he thus describes:—

"Fermentation," he says, "has not taken place, at least it has not been complete, and we must therefore provide for its renewal. Sugar, tartar and salts are defective, and we must supply them in sufficient quantities to produce an energetic fermentative movement; but before doing so we must not fail to observe one necessary precaution, viz. to shake the liquor well so as to disintegrate its component particles as much as possible.

"The mode of treatment is twofold, and this is the first proceeding:—Suppose we have a cask of wine showing symptoms of ropiness: drive a hole through the bung with a spile, to allow the free escape of the confined air.

"Run off a pailful of the affected wine, so as to leave plenty of room in the cask for shaking up the wine vigorously.

"Agitate it briskly by moving the cask about for a space of five or six minutes.

"Remove the bung to allow the escape of the froth thus formed, and repeat the operation until no more froth appears.

Then comes the second part of the process—the artificial renewal of fermentative action which will not set in unassisted. Run off a pailful of the wine. Make it as hot as possible without permitting it to boil. Add to this about 250 grammes of cream of tartar dissolved in some warm water. The tartar is hard to dissolve if put into the wine without preparation. Add a kilogramme of sugar, and 250 grammes of catechu, an harmless tanniferous substance which never produces any ill effects on the wine. Pour the whole mixture into the wine, and let it stand undisturbed until the ropiness has disappeared and the wine again become limpid.

"It is essential that the substance thus added should have time to work. Consequently, a sufficient interval must be allowed to elapse before racking off."

In this process the only really useful points are the agitation of the wine and the addition of tannin, which it appears to us might be more suitably and more economically employed in the form of grape-seeds, than in that of catechu. The tannic alcohol of L. Barral (sec. 10, p. 376) would be well adapted for the purpose. The renewal of fermentative action by the addition of fresh sugar appears to us more hazardous than useful.

M. Marchard confirms the assertion that wines thus affected often recover themselves spontaneously under the effects of a decrease of temperature, or are cured by simple agitation of their volume, as by allowing the wine to fall from a height in racking, or rolling the casks. Symptoms of ropiness are often observed to disappear after the wine has been carried some distance over stony roads. As the most efficacious mode of all, he recommends passing the wine through fresh *balsa*, a process which combines agitation of the liquor with the addition of tannin.

It is proper to observe here that sulphurization in any shape and form is unsuited to wines thus affected. The combustion of the brimstone, producing sulphurous acid, deprives the wine of the oxygenating influence of the air, which experience shows is peculiarly necessary to it. On this point all authorities are agreed, and it may be safely laid down as a rule, that the casks used for racking off wine thus affected should not be sulphurized.

To recapitulate: whatever may be the cause of ropiness in wine, its existence is evidence of a certain disregard of the correct principles of wine-making; but, on the other hand, the preventive or remedial means which it necessitates are by no means difficult of application. These methods consist of the agitation

[1] It would be more correct to say, the conditions under which the disease shows itself.

of the wine in contact with the air, and the addition of tannic alcohol in sufficient quantity, which may be determined by previous experiment on a small scale. Lastly, sulphurization in every form is prejudicial and must be avoided.

### 18.—Sour-Sweetness.

It is certainly a remarkable fact that a description of the disease known in all our wine-producing districts under the name of *agre-doce* (sour-sweetness) is not to be found in any œnological work, not even in the memoir of P. Rebello or in the work of the Viscount de Villarinho de S. Romão, although both of these authors were intimately acquainted with the Douro wines, in which it is most common. It seems to us that the former of these authorities is disposed to confuse "ropiness," which is never seen in the alcoholic wines of the Douro, with "sour-sweetness," which is extremely common in them. Speaking, rather unintelligibly, of the first-mentioned disease and endeavouring to explain his theory of it, by which he renders the passage in question still more obscure, he specifies, as a characteristic of "ropiness," a certain *sickly sweetness with a disagreeable admixture of bitter;* and suggests, as a remedy, the addition of brandy on the first appearance of the malady, a remedy very generally administered in strong doses in cases of sour-sweetness.

M. Ferreira Lapa is the only Portuguese writer known to us who makes mention of sour-sweet wine, which, with somewhat undefined notions, he proposes to treat by the methods employed in cases of *acetation*, under the supposition that acetic acid is the predominating element in both diseases.

Amongst foreign writers, not one has specially treated the peculiar form of affection which constitutes sour-sweetness. Yet the disease exists, and is common in the Douro wines, particularly during seasons of excessive heat, and in localities that yield the richest and fullest-bodied wines. "Sour-sweetness" holds the same place amongst the Douro wines as bitterness amongst those of Burgundy. The Viscount de Villar Allen, to whom the writer applied for information respecting the diseases most common amongst the wines of Douro, in a letter in which he was obliging enough to reply to these interrogatories, states that "Sour-sweetness is the worst of all those diseases, and is the more to be dreaded as it invariably shows a preference for the best wines, that is to say, those from the best soils and best vintages."

We have not been able as yet to collect facts sufficient for a complete and conscientious prognosis of this disease, but we feel assured that it is altogether distinct from those above described, and properly cannot be classed with any one of them.

The conditions under which sour-sweetness makes its appearance lead to the supposition that it differs considerably from *acetation*, to which however it bears most resemblance. In unusually hot seasons, when the grapes have attained an extreme ripeness, when the *must* is very thick and saccharine, when the vintage operations have been conducted beneath a scorching sun, and when the *must* has risen to excess in the process of vinification, *sour-sweetness* generally shows itself in the wine grown on spots most favoured by the sun's action. The Viscount de Villar Allen informs me that this affection appears not only in the tanks and vats in the country, but often, months after the vintage, in the stores at Oporto, sometimes, even two or three years after the wine has been bottled, in England, and he adds that the vintages most remarkable for showing this ulterior effect in bottle of late years have been those of 1851 and 1854.

The vintage of the present year, 1868, will probably supply numerous examples of *agre-doce* amongst the Douro wines made previously to the heavy rain-fall of the second week in September. The extreme heat, the prolonged drought, the remarkable intensity of the solar action, all accelerated and precipitated the ripening of the fruit, stimulating it to the elaboration of its constituent principles, inspissating the juice and rendering it difficult to ferment properly, so that it was often impossible to keep the wine in the tanks clear to the zero point of the must-gauge. These are conditions which favour the development of sour-sweetness; the wine becomes weak, turns, and acquires a peculiar flavour of sweetness commingled with a certain very disagreeable acidity.

What may be the nature of the changes experienced by the elementary principles of the wine, which manifests itself in this remarkable form of constitutional derangement, we cannot say, not having hitherto had an opportunity of studying wine thus affected. During the present year, amongst certain of the writer's wines destined for the liqueur-case, was a white wine which showed symptoms of *agre-doce*. Here, the acidity, which was present in combination with a peculiar kind of sweetness, appeared *not* to be caused by acetic acid, neither was the smell of the kind characteristic of acetic action. Not having had previous experience in cases of this sort, we treated it after the fashion adopted by the growers of the Douro, where, as we have said, the malady is most common, making such alterations in the mode of treatment as appeared desirable. Having determined by analysis the proportion of acid in the wine during vinification, and also when in an affected state, we were enabled to ascertain the excess of acid present in the latter. Taking a quantity of pure carbonate of potash just sufficient to neutralize the said excess of acid, we mixed it with a small quantity of white argillaceous earth, well washed and diluted in a little water. After having been well mixed with the wine, the earth became precipitated by degrees, leaving the wine perfectly clear and free from acidity, but paler in colour, and with a rather peculiar "dryness." After this we added 2 per cent. of brandy of 10° by Tessa, clarified the whole with white of eggs, and racked off into a fresh cask. To day the wine is bottled, in good condition and improving, but not as good as it would have been had it not been attacked.

An inspissated condition of the *must*, and a comparatively high temperature at the commencement of fermentation—referable to the heating in the tanks of the grapes picked beneath a scorching sun, rather than to direct atmospheric influence—are unfavourable to the normal development of fermentation and lead to a derangement of the accompanying phenomena. The transformation of the sugar is not complete, and an acid is produced which appears to differ from those formed in the regular processes of vinous fermentation, being probably *lactic acid*, which is met with in abnormal cases of fermentation. Eventually, derangement shows itself in the wine, either in the tanks or at a later period in cask or bottle, under the influence, modified by circumstances, of these fermentative principles, which appear to adhere to the wine in spite of rackings and clarification.[1]

The parasite figured by M. Ferreira Lapa in the illustration which accompanies his article on "Sour-sweet Wine," in his "Technologia Rural," appears to us to be a peculiar form of alcoholic ferment, to which M. Pasteur attributes a slow and injurious action on sugar, and which is met with in the abnormal fermentation—at once lactic, manitic and alcoholic—of beet-root.

In place of laying stress upon vague conjecture, it seems preferable to direct the attention of observers to this singular affection of our finest wines. If it be proved to originate in the inordinate saccharine richness of grapes gathered and fermented at an exceptionally high temperature, it might be possible to obviate the evil by taking the precaution to immerse the grapes in water before placing them in the tanks. The water which would then adhere to the husks would prove beneficial rather than otherwise to the process of fermentation, as it would dilute the consistency of the *must*.

We will now consider the modes of treatment pursued in the Douro and at Oporto, it cannot be said for the cure, but for the economization of wine attacked with sour-sweetness. Upon this subject the Viscount de Villar Allen writes as follows:—

As soon as the first symptoms of *agre-doce* are observed the wine is *smothered* with brandy, as in the preparation of *geropiga*, so that all fermentative action is at once arrested. The wine is thus saved, but is excessively alcoholic, so that it can only be used as brandy; it may be employed for mixing with new wine, or for *remusting* at next vintage if desired.

Another method is to use white fullers-earth. In small quantities not exceeding 1 kilogramme to the pipe of 534 litres it is found efficacious. To this no brandy is added until after the acidity has disappeared. For the effective neutralization of the acid principle it is necessary that the fullers-earth should contain carbonate of lime or magnesia, in which case the salt resulting therefrom, being soluble in wine, will communicate to it a peculiar taste. Pure argilla or kaoline would be preferable, the excess of acid having been previously neutralized by a moderate use of carbonate of potash. In every case remedies of this class should be applied with great circumspection.

Where time permits, the use of sulphurous acid gas is to be

[1] After committing the foregoing description to paper, the writer applied to a friend, M. José Maria da Viega Cabral e Sampaio, de Casal de Loivos, one of the best known Douro growers, for information respecting the *agre-doce* which frequently shows itself in the best wines of that famous district. He replied thus:—"Unquestionably the wines made at Roeda, when that *quinta* belonged to M. A. Pinto Soveral, were affected with *agre-doce* in very hot seasons. But this is not an exceptional case. All wine grown in the hot zone of the wine country, including the different riverside localities with a southern aspect, are affected in this way in hot dry seasons, unless fortified when placed in the casks. Still the wine at Roeda was not affected when some of it which had been purchased by A. B. Ferreira was attacked by *agre-doce* at Coval.

"In 1825-6-7 all the wine at the quintas of Amarella, Luiz di Aguiar, Coval, Sobradellas, Valle Bemfeito, Bomfim, Tojo and Roeda were thus affected and passed from a state of acetic to putrid fermentation, although a certain quantity of brandy had been given them. In 1826, I commenced making my own wine at Roeda, and saved the crop of 1827 by adding two *almudes* of brandy per pipe in the tank."

preferred, as the *mutismus* or complete arrest of fermentative action is thus secured. As many matches may be consumed as the wine can take. For a description of the process the reader is referred to sec. 9, p. 372.

We may add that the methods above described must invariably conclude with a careful "clearing" and the running off of the clarified wine into a fresh cask.

Besides the *diseases* above described, all of which are caused by more or less deeply-seated affections of the constituent principles of the wine, originating in the action of certain foreign ferments which become intermixed therewith in various ways, there are *defects*, more or less marked, to which wine is subject, and which invariably arise from some neglect of proper hygienic precautions, such are mustiness, and taste of the wood, and other peculiarities communicated to the wine by simple contact. These never corrupt its most valued properties, but still, if neglected, they are apt to lead to serious consequences.

Mustiness or any other exoteric taste, in the majority of instances, may be got rid of by filtering through good vegetable charcoal. The charcoal should be carefully picked over, broken into small pieces and placed in sufficient quantity in a funnel inserted in the bung-hole of the cask destined to receive the wine. Vegetable charcoal is a powerful absorbent of organic odours, and at the same time and in a still greater degree, of colouring matters. Wine filtered through vegetable charcoal consequently loses some of its colour. After filtration it should be "cleared" and a modicum of brandy added to it.

Some writers recommend the use of good oil, in the proportion of one litre per pipe, to be mixed and stirred up with the wine, which afterwards should be "cleared," and racked off into a fresh cask. *Good* oil never communicates any taste to wine, as it is perfectly insoluble therein; at the same time it dissolves and absorbs certain oily essences in the wine which impart to the latter a bad taste.

Since the use of sulphur has become common as a antidote for the oidium, the brimstone which adheres to the husks of the grapes not unfrequently produces sulphuretted hydrogen gas during fermentation, and the latter, becoming dissolved in the wine, imparts to it a taste of rotten eggs. This may be dissipated by frequent racking and stirring of the wine, or by passing it through a rose in filling the casks, so as to divide the current of the liquid as much as possible. In weak wine this of course entails the risk of acetation. In this case it would be preferable to pass a current of carbonic acid gas through the wine by a process well known to chemists. The application of this method was suggested by M. Maumené in his treatise, and an illustration of the apparatus required, with details, may be found in the "Technologia Rural" of M. Ferreira Lapa, vol. i. pp. 173-4.

Simple as it is, the process is not in favour with our growers, most of whom prefer racking over the fumes of sulphur as more equable in effect and more efficacious. The sulphuretted hydrogen is decomposed by coming in contact with the sulphurous acid produced by the combustion of the brimstone matches, part of it rises in the form of finely comminuted solid particles to the surface of the wine, from which it can readily be separated, and the remainder takes the form of sulphuric acid, the presence of which, in small quantity, does not harm the wine.

Amongst the defects which may be communicated to wine by the vessels in which it is kept is one which requires attention when large quantities are put in bottle. This is dependent on the quality of the glass used in the manufacture of the latter. On this point we would refer our readers to what has been said in sec. 14, p. 377.

But for all the maladies of wine, and for all the defects it may acquire, the most unfailing antidote is the care which we have before enjoined when speaking of the operations of wine-making.

Cleanliness, in all shapes and forms, and at all seasons, is the surest guarantee of the soundness and safe-keeping of every wine.

### 19.—General Remarks.

In the introduction to the second part of the present work, speaking of M. Pasteur's researches into the diseases of wines, we alluded to the tendency of modern scientific opinion to recognize a single theory for the general explanation of these affections, regarding them as the work of cognate influences, and remediable by any individual mode of treatment adapted to counteract such influences. The enunciation of the new theory is simple, and has been already given to the reader. We repeat it here for the sake of clearness. *The morbid affections of wine are identical with those now held to be of fermentaceous origin, and must be regarded as the vital work of certain organisms analogous to the ferment which produces wine itself.*

Consequently, if this theory be accepted, we must consider the diseases of wines as the consequences of fermentaceous action analogous to, but differing from, that which resolves grape-juice into wine, or as caused by living organisms which grow in the wine at the expense of its component principles, eliminating some of them, and evolving others which profoundly influence the character and qualities of the fluid.

With each disease the upholders of this theory assume the existence of a specific ferment: that is to say, a different organism, a rudimentary vegetable form, a well-defined mycoderm, which lives and feeds, after its fashion, by preying upon the essential components of the wine, and transforming them into other substances unsuited to the proper normal condition of the liquor.

This view of matters requires the acceptance of two fundamental positions:—1. The diseases of wine are of a fermentaceous character. 2. Every disease is caused by a specific variety of ferment.

It would be greatly to the advantage of œnological science if these propositions were established in a full and satisfactory manner. At present they have merely a certain amount of probability in their favour, which rests upon M. Pasteur's delicate microscopical observations of the sediment of affected wines. Our knowledge of fermentation is still very imperfect, and by far the larger number of the phenomena classed under this head are mysteries into which science has not yet penetrated. Vinous or alcoholic fermentation is well understood, and in this case theory is in accordance with observed facts. The organic character of the ferment, its *modus vivendi*, the products to which it gives birth, are sufficiently understood to enable us to encourage or resist its action at will. The same may be said of acetic fermentation. But of other abnormal varieties, which are assumed to be the proximate causes of disease in wine, it cannot be held that our knowledge is exact, M. Pasteur's admirable researches notwithstanding.

Unquestionably, the first symptom of every form of disease in wine is a certain turbidity. In sickening, every kind of wine turns thick, as in actual fermentation, and throws down a more or less copious sediment, which, under the microscope, shows, amongst the crystals of tartar and amorphous particles of organic matter forming the lees, a large quantity of organic corpuscles of varying aspect—some of them globules, spherical, ovoid, more or less elongated or pyriform, either separated or in strings—others articulated forms, like the stalks of cereal plants, either elongated or in separate articulations—these are the organic corpuscles, which, from their resemblance to the ferment of vinous fermentation, M. Pasteur holds to be the prime motors of the abnormal forms of fermentation, and consequently of the diseases, of wine. As we have before observed, his microscopical researches have led him to believe that in the sediments of wines affected with different forms of disease there is in each case a predominance of some one particular form of ferment. Thus in *acetation*, the *mycoderma aceti*, in the form of short articulations somewhat drawn in or compressed in the middle, and most frequently connected together in strings, is most abundant; in *turning*, we have filaments of extreme continuity, formed by the junction of elongated articulations, resembling wheat-straws, and somewhat analogous to the filaments which appear in lactic fermentation; in *ropiness* we have another form of parasite—chaplets of spherical globules of diameters varying with the nature of the affected wine; in *bitterness* there is a marked excess of elongated articulations, bigger and with more marked articulates than those in "turned" wine.

If the appearance of each variety of parasite were restricted to that particular state of the wine of which it is supposed to be the cause, it would be easy, with the aid of the microscope, to distinguish the nature of such affections before they had made much progress. Unfortunately, in most cases, the sediment of wines appears as a confused assemblage of rudimentary organisms, extremely difficult to distinguish, even by the most practised observers.

Microscopical investigations of the sediment of affected wines are indisputably of great utility, when they are carefully made, collated with the other phenomena which manifest themselves in the wine, and considered without partiality. It is indeed probable that they may some day lead to a full and assured knowledge of the trûe causes of the affections that destroy our wines. M. Pasteur has done valuable service to the cause of œnology by opening up this line of research; still, we must not flatter ourselves that he has thereby obtained an indubitable revelation of the real nature of all the causes at work. It may be that the mycoderms which he has observed and described *are* the causes of disease in wine, but they may, too, be merely concomitant symptoms of these maladies. We shall not enter upon a discussion of this question here; even if the writer felt qualified for the task, the data requisite for a full and profitable discussion are wanting; but we must confess that we do not feel convinced that every form of disease in wine is caused by M. Pasteur's my-

coderms, nor that a specific variety of ferment exists for every disease. The new doctrine is attractive in its simplicity, but it is not conclusive. In science, as in all other mundane matters, we must be cautious not to be misled by appearances.

Were the two propositions respecting which we have expressed our doubts indubitably correct, the solution of the various questions depending upon them would be easy. How shall we prevent the appearance of those vegetable growths which originate disease? How shall we destroy them when once they have appeared?

The first of these questions involves another, which has been widely discussed by men of science, but, as it would seem, without any definite results. We allude to the question of spontaneous generation. Do these living forms originate spontaneously, in certain favourable circumstances, independently of the existence of a parent germ of the same species? Hitherto experience has not confirmed this belief, so that by far the larger majority of naturalists hold that spontaneous generation, or *parthenogenesis*, has no present existence on our planet. It is admitted that all living organisms come of a parent stock; in other words, that the germ or seed must be evolved.

The germs or seeds of the mycoderms and ferments found in wine are, in all probability, transported, for the most part, by the atmosphere, and lodged on the grapes themselves — in the tanks and vats, in the casks, and in every other place to which the air has access. The various precautions above described for preventing, as far as possible, any contact of the wine with the air, must necessarily tend to diminish the chances of the wine becoming a receptacle for these noxious forms of vegetation.

On the other hand, these growths, like all other *living* organisms, are insoluble, and therefore are precipitated when the wine clears itself, either naturally, or with the aid of artificial clarification, and form the lees, which are carried by their specific gravity to the bottom of the casks. In either case, racking offers a simple and effectual mode of separating the wine from them. The most scrupulous cleanliness in all the manufacturing processes in the buildings, tanks, presses, casks, &c., is equally indispensable to the exclusion of the foe.

In regard to the second question, the decision of experience is favourable. It is now a recognized fact that all fermentative action, in every kind of alcoholic liquor, ceases when exposed to a temperature above 167° Fahr. (75° C.), and that it is not renewed so long as proper precautions are taken to preserve the liquor from contact with the atmosphere. Upon this fact, which practice daily confirms, M. Appert based his method of preserving provisions, since so extensively adopted in France. M. Pasteur is now endeavouring to popularize and extend the application of the same process to the conservation of wine, so as to secure it against the various morbid influences which imperil its safety.

We shall devote the next chapter to an explanation and discussion of this process, in the hope that it may prove of service to our wine-growing community.

### 20.—The Process of Heating Wine.

We have now to consider the modes of subjecting wine to a moderately-elevated temperature, with a view to the improvement of its lasting properties, by the prevention of morbid changes in it, and the increase of its constitutional soundness, without depreciating its most highly-prized characteristics.

This idea has made rapid progress of late years. "Heating" now takes a place beside "racking," "clearing" and "brandying," for which latter process it is, to a certain extent, a substitute.

The practice of applying heat to wine is by no means new. Not to speak of its use amongst the ancients, of which a few vague and cursory notices have come down to us in the writings of Greek and Latin authors, it is well known that "heating" has long been practised in the Island of Madeira, and at certain establishments at Lisbon and in the south of France, with the object of making the wine *mature* more rapidly, and that it has always been attended with excellent results when applied to wines of a certain alcoholic strength.

As we have before said, the process has a twofold object—the conservation and the improvement of the wine. The latter has hitherto been the end sought by the traders of Madeira, Lisbon, and Cette; the former is becoming more common in France since the researches of M. Pasteur have demonstrated its utility; but it was suggested, and tried experimentally, by Appert, by Gervais, and by M. de Vergnette Lamotte.

If the improvement and conservation of *strong* wines, like those of Madeira and their congeners, be a matter of great commercial importance, the conservation of light, natural-made wines, which are more readily affected by the contingencies and maladies to which they are subject, is of still greater value; not, indeed, that the production of the latter or the demand for them is such as might be desired, but because they constitute a more essential element of our public food supply. We shall, therefore, in the first place, consider in detail the heating process, in its relation to the conservation of wine.

In every industrial process, a knowledge of the theoretical principles upon which the process itself is based, is of great practical utility, so long as these principles have been deduced from carefully-observed facts. Oftentimes, in industrial operations, practice precedes the recognition of theoretical principles, being itself the result of mere conjecture, of purely empirical experiment, perhaps of chance. Whether the application of heat to the preservation of wine is referable to a like conjectural origin, we shall not pause to inquire.

Appert, who was a skilful practician and the inventor of a process now much used in the preparation of preserved provisions, records some attempts made by him to preserve wine by heating it, in bottle, in a water-bath, to a temperature of 158° Fahr., which were attended, in the case of the Burgundies with which the experiment was made, with excellent results.

The following is a brief sketch of his proceedings. Three lots were made of the same wine. Of these, the first was bottled in the ordinary manner, and without any special precautions, to serve as a standard: the two other lots were subjected to a temperature of 70° C. (158° Fahr.) by placing the bottles in a water-bath. Subsequently the latter were forwarded to Havre, with a request that one lot might be shipped in some vessel bound on a distant voyage, and the other placed in store. Twelve months later, after the second lot had performed a voyage to the West Indies and back again, the three were opened and tested. The wine which had not been heated was still unmistakably "new;" that left at Havre in store had "matured" but still possessed its natural *bouquet;* whilst the remaining lot, which had been to the West Indies and back, was greatly improved in delicacy of flavour and aroma. These experiments were neither continued, nor turned to any practical account. Subsequently, in 1827, Gervais published an account of "The Use of the Digester in Improving and Preserving Wine."

This digester was a circulatory apparatus, by the aid of which a current of wine could be subjected to a given temperature, in its passage from one cask to another. The suggestion led to no practical results, and need not be further discussed here. It should, however, be observed that the theory of the process approximated to that now accepted, as its design was to secure the destruction of the fermentative agency through the instrumentality of heat; and, as we have before remarked, all œnologists are now agreed that fermentation is the cause of the maladies to which wine is subject.

In 1840, M. de Vergnette Lamotte repeated Appert's experiments in Burgundy, and in 1850, published an account of the results obtained and the observations made in the matter. His experiments combined those of Appert, and demonstrated that wine after having been subjected to a temperature of 120° to 168° Fahr. had escaped ulterior changes, while other wine of the same description, not so treated, had deteriorated. In 1865, M. Pasteur, who had been induced by the French Government to undertake an investigation of the diseases of wine and the most efficacious modes of prevention, and had arrived at the conclusion that these changes—one and all—were the results of abnormal fermentative action caused by certain mycoderms, essayed to destroy the vitality of the mycodermic germs by the application of a degree of heat which should be insufficient to exert a detrimental influence upon the wine itself. Experiment confirmed his anticipation. In April of the same year a *brevet d'invention* was accorded him for the discovery of a process of heating wine for the purpose of preserving those sorts most subject to affections and maladies of a fermentaceous origin.

Although the process, as we have seen, was not new, nor entitled to the distinction of a patent, M. Pasteur nevertheless rendered good service to commerce, by directing the attention of œnologists to a question of great importance to wine-growers, and by starting a new theory of the diseases of wine which bids fair to lead to very important results.

During the last three years past, the new process has been widely discussed; it has been tested experimentally in a variety of ways; many new processes and forms of apparatus for the economical application of heat to wine have been devised and tried; and now everything would seem to prove that the process is destined to render valuable service to the wine-growing community.

We propose, without entering upon a theoretical discussion, to give such details as are requisite to enable our growers practically to apply the process in accordance with modern theory, to the conservation of *light, natural-made* wines, as it has long

been applied in Portugal to the preservation and amelioration of *strong* wines.

We all know that amongst the essential and characteristic properties of certain wines, are some which contribute materially to the estimation in which the wine is held, but which are extremely sensitive and evanescent in their nature—such are *bouquet*, fruitiness, and brilliancy of colour.

Heat, combined with atmospheric action, would assuredly affect these peculiar qualities, and probably deprive the wine of some of its most highly-esteemed characteristics. This is one of the chief hypothetical difficulties of the new process. Were it necessary, in order to secure the wine against ultimate changes, to subject it to a temperature of 212° Fahr., the *bouquet* and delicacy of flavour would no doubt suffer.

Luckily, the presence of alcohol, and even of certain acids, seem to assist the action of heat in destroying and rendering inert the fermentative principles; so that M. Pasteur, who started with the supposition that a temperature of 167° Fahr. was necessary to the success of his experiments, was speedily led to reduce it to 122°, and ultimately to 112° Fahr. during a period of exposure so limited as to be almost instantaneous. A series of experiments made by the writer of the present work in the course of 1867, in which bottles of white and red wines of an average alcoholic strength of 12 per cent. were placed in a water-bath, at a temperature of 140°, and exposed to the sun for a week, in the month of June, when the maximum temperature was over 120° Fahr., confirm the belief that this temperature suffices for the safety of the wine without endangering its *bouquet* and flavour. As might be expected the wine exposed to the sun underwent a change of colour, turning from a winey red to ruby, and acquiring at the same time increased dryness and a taste of "age." None of the wines so treated were remarkable for *bouquet;* and in respect of the retention of this quality the writer is unable to speak from experience. The white wine was manifestly improved—becoming Madeira-like, with greatly increased brilliancy and limpidity.

Amongst the effects of heating wine, besides those due to the direct and immediate action of the caloric, we must expect others which result from atmospheric action, when the heating process is carried out under circumstances which do not permit of the complete exclusion of the surrounding air. When the heating is effected by the solar rays, light exerts a powerful influence upon the colouring matter, tending to modify and destroy it. According to M. Pasteur, this action is only appreciable when the colouring principle is in contact with the oxygen of the air, so that it becomes oxygenated by actinic influence. Chemical researches have since shown this view to be correct.

But there are other substances in all wines, which, without knowing much about them, we designate *extractive matters*, which are present in variable proportions, and which also are influenced, either by chemical action caused by the application of heat, or by the increase of temperature during exposure to atmospheric action. From this point of view it would appear that the heating process would conduct to different results depending upon differences in the nature and composition of particular wines. This, which exactly accords with experience, need not be held to detract from the practical value and utility of the process.

The multiform tests and trials to which the process has been subjected, from the days of Appert until now, that is to say, for more than a century, have demonstrated that a rise of temperature to 122º Fahr. or thereabouts, renders the fermentative principles inactive, and that wine thus treated, so long as it is protected from the air, is safe from those maladies to which it would be subject in the absence of such precautions. In respect of the *bouquet* and delicate *goût* of certain wines the application of heat may no doubt effect a sensible change by rendering the wine extremely "dry," particularly in cases where the temperature has been carried higher than necessary. A temperature which does not exceed 122° Fahr. even may act detrimentally upon delicate wines.

M. Terrel de Chènes, one of the most distinguished practical œnologists in France, and one of the most independent in the expression of his opinions, in an article published in November, 1868, writes as follows:—

"Lastly, if we collate the recorded observations of Appert, Gervais, M. de Vergnette Lamotte, M. Pasteur and others, we shall be constrained to admit:

"1st. That in the *majority* of instances wines which have been heated are superior to non-heated wines drawn from the same casks, and kept under precisely similar conditions.

"2nd. That much of the non-heated wine deteriorates whilst the heated wine improves.

"3rd. That in a small number of instances the heated and non-heated wines are alike in quality.

"4th. That in still rarer instances, the heated wine acquires a certain taste of *dryness*, which is never observed in non-heated wine.

"The conclusion to be deduced is obvious to every impartial mind."

Thin, alcoholically-weak wines, rough and "new," like those of the Minho and others, which are drunk soon after making, are never worth heating, and, as it appears to us, never should be subjected to the process, as the trifling improvement thus effected in their durability, and the delay caused in their consumption, is objectless. In this class we must not include the excellent wines now made at Basto, and Ribeira do Tamega, for Brazil, to which heating is essential on account of the rough usage they sometimes experience.

Ordinary wines, of great body and moderate strength, containing over 10 per cent. of pure alcohol, which are rich in extractive matter, and prone to rise on the approach of hot weather, should be greatly improved by a moderate heating without exposure to the air. The albuminous substances which they hold in suspension become coagulated by the heat and precipitated, while the fermentative organisms lose their vitality. When the wine has become clear it should be racked off into good, sound, fresh casks, and preserved from atmospheric contact.

Delicate, natural-made wines also gain in respect of their keeping properties by a moderate heating, never exceeding 122° Fahr., but, on the other hand, there is a great risk of their losing some of their most esteemed characteristics in the process. These results are confirmed by experiments made with Burgundian and Bordeaux wines.

Strong alcoholic wines, which have been much fortified, have no need of heating when the alcohol is in excess of 18 per cent., as this is a sufficient guarantee of their sound keeping. Long experience has shown, however, that in respect of ripening and maturing, white wines gain as much by a short exposure to solar action or to an artificially-increased temperature for a few months, as they would in as many years if kept in ordinary cellars. The same cannot be said of red wines, for although they are improved in many respects by heating, they at the same time acquire a peculiar taste indicative of something artificial. This is most observable in stove-heated wines, and is scarcely, if at all, perceptible in those which have been heated by the sun.

Having made these few general observations, we must now describe the mode of procedure, and the apparatus required for heating wine in bottles upon a small scale. It may be performed in a water-bath, or a stove. In describing the operation we shall follow the directions given by M. Pasteur.

The wine to be heated may have been some time in bottle, or, it may have been lately bottled. Whether it be sick or sound the process is the same. If it has been long enough in bottle to form a deposit or sediment, it is best to separate it therefrom by decanting it into fresh bottles. This done, the bottles are corked, and the corks fastened down with string. The bottles are then placed in the water-bath. Here it should be observed that to avoid any inconvenience arising from the dilatation of the liquor, a space of about three centimetres should be left in each bottle between the bottom of the cork and the wine, also, to prevent the bottoms of the bottles being in immediate contact with the metal work of the bath, they should be stood on wooden bottoms pierced with holes, to allow of the free passage of the steam. The bottles should be plunged in the hot water up to the mouldings on the necks, and with them should be placed a similar bottle full of water, with a small thermometer passed through its cork, so as to indicate the exact temperature of the contents, which will be the same in all the bottles.

As the wine dilates it fills the vacant space in the necks of the bottles, and if this be insufficient, as it cannot drive out the corks which have been tied down, as we have said, it makes its way in between the cork and the sides of the neck, and a small quantity very probably is spurted out. This is of no importance. When the bottle-thermometer shows that the desired temperature, say 120° to 140° Fahr., has been attained, the bottles are removed, and fresh ones set in their places, care being taken to warm them a little first so as to avoid breakage of the glass.

As the bottles become cooled after their removal from the bath, the fastenings may be cut, and the corks driven home to their proper places. Great care should be taken that the wine is not injured in the process. To those who try it experimentally, we should suggest the advisability of keeping some bottles of the same wine unheated, to serve as a standard of comparison in estimating the practical results of the operation.

The heating process may also be effected in any sort of stove, so long as its arrangements admit of the maintenance of a uniform rate of temperature, which may be ascertained by the employment of a thermometer fixed in a water-bottle as above described. It is indifferent whether the heat be applied by means of steam or hot-water, or by hot-water pipes or pipes

containing hot air, steam, or smoke, so long as the space occupied by the bottles is kept at a uniform temperature.

Heating wine in bottles may be effected in a stove, as well as in a hot-bath, and on a larger scale. This is the mode usually adopted in the trade. An oven of some sort is built so as to allow of its being hermetically closed. It is formed of materials which retain heat well, so that it may be heated economically, either by steam or hot-water pipes, or by flues communicating with a chimney outside. In these cases it is better to have the wine in small casks rather than in bottles. Stoves of this kind are used in Madeira, and at Lisbon, for heating wine to give it "age."

One essential condition to the good result of stove-heating is, that the initial temperature to which the wine is submitted should be above 104° Fahr., so that the fermentative principles in the wine may not be stimulated into activity by exposure to a degree of heat favourable to their growth.

In our climate nothing is easier than to effect the process by

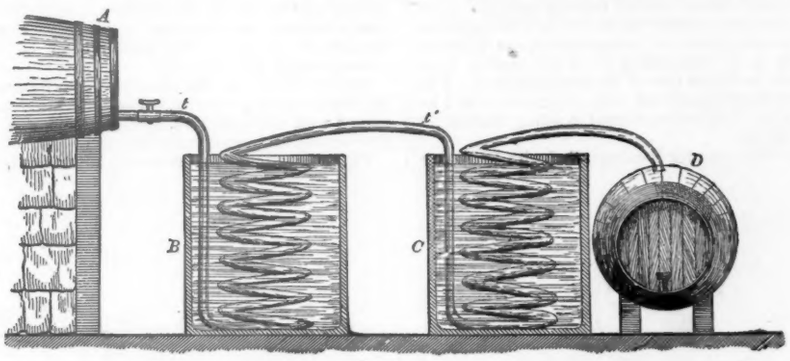



Fig. 1.

solar action, as the degree of heat thus attainable, not only in summer, but at other seasons, is greater than is necessary for the improvement and preservation of the wine. The bottles to be heated may be placed in a wooden case, painted black inside, and covered over with glass. When the sun's rays strike vertically or nearly so upon it, a very short time will suffice to raise the wine to the requisite degree of temperature, which may be ascertained as before by the use of a bottle thermometer. In place of a box we may use a small house with a glass roof; the greenhouses in our gardens would serve for the purpose.

As our trade in bottled wines is still very circumscribed, the processes just noticed have necessarily but a limited application. For us a mode of heating by other forms of apparatus has a greater practical importance. Some of the latter deserve notice.

In the writer's report on Class lxiii. of the International Exposition of 1867, pp. 187 and 188, mention was made of the old-fashioned apparatus of Gervais, which had been set aside as faulty in construction, and a description was given of those of Brot, and of Vinas and Giret de Bessières.

It is unnecessary to speak further of this, as better forms have since been brought out.

M. de Vergnette has suggested for the heating of ordinary wines a modification of the apparatus of Gervais, proposed by M. Velten, of Marseilles, a very simple and comprehensive arrangement in which the principle of the old apparatus is alone retained. Between the cask to be emptied and that which is to receive the wine, he interposes an apparatus for raising the temperature of the wine as it flows from one to the other to the desired point, and to reduce it again to its ordinary temperature. This was the principle of Gervais' apparatus, as it has been of other more recent inventions.

Fig. 1 represents Velten's improved arrangement. The wine to be heated, on leaving the cask, A, flows through a spiral tube *t*, which is plunged in the hot water in the warmer B, kept at a suitable temperature by steam or hot-water pipes, or by placing it in immediate juxtaposition with a small furnace. The wine to be heated enters at the bottom of the coil, rises in it as the temperature increases, and flows out at the top into another spiral tube *t'*, which is placed in a similar fashion in a cistern of cold water. This is kept constantly supplied with fresh water, on the principle of our refrigerators and alembics. This coil conducts the cooled wine into the cask D, in which it is definitely to remain.

M. Terrel de Chènes, an experienced grower and an indefatigable experimentalist, of whom we have spoken before, has proposed an apparatus for heating wine intended for bottling, which he calls an *œnotherm*. It may be used for heating wine in the wood, and in some respects is more simple than the apparatus just described. In both instances, the design has been to solve Gervais' problem, and to produce a certain determinate temperature in a current of wine flowing from one cask or receptacle to another, without exposure of the wine to the air, and in such a way that the liquor may be again at its ordinary temperature when it enters the cask in which it is to remain.

M. Terrel de Chènes solves this problem, as it appears, in a very simple and efficacious manner in his *œnotherm*.

Between the cask which contains the wine to be heated and that which is to receive it after the process, he places a circulatory apparatus, so arranged that the wine may pass, first, through a hot chamber, in which it is raised to the temperature necessary to the destruction of the organic germs or ferments, and, afterwards, through a cooling chamber where it is again restored to its ordinary temperature. In order that the elevation of temperature may be effected as speedily as possible, the wine is divided into as many separate currents as may be considered desirable, and the whole operation is effected without exposure of the wine to contact with the external air.

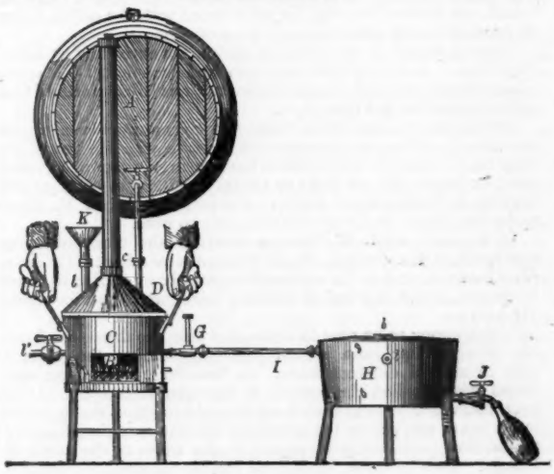



Fig. 2.

When the wine is in bottle it is placed first in a hot-water bath, and afterwards in a cold bath, the temperature passing from 120° to 69° F. It is then corked and sealed with as little delay as possible.

"Heating" wine which is to remain in the wood may be effected simultaneously with "racking," and does not require more time than would be needed for the latter operation under ordinary circumstances. The heat is applied by means of small hot-air pipes running longitudinally through the larger pipe which conducts the wine from one cask to another.

The arrangement of the apparatus may be readily understood without the aid of diagrams; but, for the greater convenience of our readers we reproduce in fig. 2 the inventor's sketch of the

*œnotherm* arranged for heating wine before bottling, with his description and directions for use :—

Fig. 2 shows the apparatus at work. A vertical section is given in fig. 3. A is the cask containing the wine to be heated and bottled. B is the calorifactor contained in furnace C. It is filled with water through pipe *b*, and is supplied with a stop-cock at *b'*. C is the furnace for heating B. The fuel is introduced by lifting cupola of chimney C. To facilitate the removal of the furnace, it is provided with handles at D D. E is the circulatory coil of warmer B. It is formed of spiral tubes traversing the heater B, and connected with external tube E'. G is a thermometer, to show temperature of B. H is a refrigerator filled with water of a temperature as low as can be conveniently obtained, which flows in at *l* and out at *l'*. I is a flexible tube connecting spiral tube in B with that of the refrigerator H. J is the spiral of the refrigerator, provided with a stop-cock at I to fit the neck of a bottle. K is a funnel used in filling warmer B with water through pipe *b*.

*Mode of working*.—The warmer B being filled with hot water at a suitable temperature, communication is opened between the cask and the spiral E by means of flexible tube I. The wine circulates through E, and is heated to the temperature indicated by thermometer G ; it then passes through the second flexible tube I, into spiral of refrigerator H, through which it flows by the stop-cock F into the bottle fitted to the latter to receive it.

The diameters of the spirals and stop-cock are so arranged that three bottles can be filled in two minutes, thus allowing time for the operator to cork each bottle as soon as filled. The stop-cock F being open, and the furnace well managed, a medium heat of 120° to 140° F. can be maintained. If a higher temperature is desired, the stop-cock is partially closed, so as to retard the flow of the wine. The thermometer G shows the increase of temperature thus obtained.

The cleanliness of the tubes and coils is secured by connecting the escape-pipe with *b'*. The hot-water reservoir is also connected with the coils, and a jet of steam can, when needed, be sent through the latter, escaping at J.

Fig. 4 represents the mode of adjusting instantaneously the

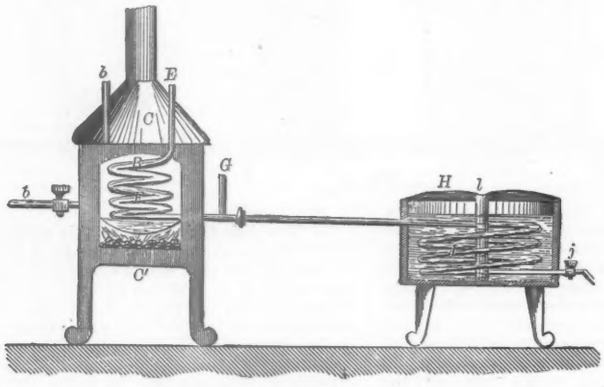



Fig. 3.

Fig. 4.

ends of the flexible tubes. M is a collar fitted to each extremity of the tubes. These are formed into male and female screws, which are screwed up and the joint closed with the collar, so as to prevent the escape of a single drop of wine.

The apparatus is portable, the weight not exceeding 25 kilos. (half cwt.) It is speedy in its action, and economical. It costs about 18,000 reis, and consumes about 45 reis (1½*d*.) worth of fuel to each barrel of 228 litres.[1]

In all these apparatus the tubes and coils are made of tin, or are tinned. Short as the contact of the wine with the heated tin may be, it would be preferable to have them of silver or silvered over, or better still, of glass or china, which might be managed cheaply and with perfect safety. Contact with tin, as M. Maumené has shown, is always unfavourable to wine.

In a recent work M. Pasteur describes the mode of using another form of apparatus, the invention of a merchant at Orleans, M. Rossignol, and as his observations may be of service to those interested in this method of treating wine, we transcribe them. He says :—

"I am happy to be able to state that this problem—the heating of wine—has been solved practically during the present year in several different ways. In Bessières, MM. Giret and Vinas have applied the process to between 10,000 and 15,000 hectolitres of wine, and they have brought together much useful information respecting the practical benefits resulting from its application, particularly in regard to the wines of the south of France. In Narbonne, M. Raynal has heated several thousand hectolitres. Other examples might be cited in France, Spain, Austria, and the United States.

"Quite recently, and by mere chance, I had the good fortune to make the acquaintance of a well-known wine merchant here in Orleans, who has devised a most ingenious and economical form of apparatus for this purpose. I am greatly deceived if it will not speedily find favour with growers and wine-merchants.

"It costs 140 francs, and heats six hectolitres of wine per hour at an outlay of 10 to 12 centimes per hectolitre. It might easily be constructed on a larger scale. The advantages of the apparatus are patent to all who see it, and as M. Rossignol makes no secret of it, and claims no proprietary rights in it, I will describe it. I have persuaded several persons to adopt it, and they are all equally satisfied with M. Rossignol as to its advantages. The apparatus, fig. 5, consists, in the main, of a vat *c c* without a bottom, the place of the latter being supplied by a boiler *k*, made of copper and tinned over, the upper part of which is prolonged in the form of an open tube passing through the head of the vat. The wine is poured into the vat around the boiler. The latter is filled with water, which is heated by means of a small revolving grate set under it. The water is raised to boiling point and heats the wine, the temperature of the latter being indicated by an attached thermometer. It is unnecessary to empty the boiler—the same water may be used again and again. The tin tube *h* should be so arranged that the water may rise in it about three-fourths of its height when the water is at its highest point of temperature. A stop-cock in the lower part of the vat permits the heated wine to be racked off through a wide india-rubber tube, as in fig. 6.

"When the vat is emptied it should be filled again at once with wine, so as to utilize the heat running from the preceding operation. When the apparatus is not intended to be used for some time, it is as well to empty it. If the interval should be much prolonged, as for example, during a twelvemonth, it is better to fill it with water and to heat the latter to prevent the formation of organic impurities there.

"The method of fitting the boiler to the bottom of the cask employed by M. Rossignol is safe and very convenient. A flat annular plate of tinned copper is soldered to the boiler, so as to form a projecting rim all round. This rim lies between two other annular plates, one of iron and the other of india-rubber, about two centimetres in thickness. The cask rests on the india-rubber plate by the chamfered ends of its staves. Another ring or hoop of iron is let into the wood of the staves. It is furnished with projections at certain distances, through which iron bolts, with screw-ends and nuts, are passed, connecting it with the bottom plate. By tightening the nuts the india-rubber is pressed up against the stave ends, so as to form a perfectly impermeable joint. Various arrangements can be adopted for the extent of heating surface presented by the boiler to the wine. These I need not enlarge upon. The revolving furnace effects a great saving of fuel.

"If the rim *s* were laid upon a bedding of tiles, and the depth of the boiler below it increased, the india-rubber would be less

[1] About 50 gallons English.

exposed to injury from the heat. Experience, however, shows that it lasts a long time.

"As wine augments in volume with an increase of temperature, M. Rossignol is unable to fill his vats completely, and the wine consequently is heated in presence of a certain (limited) volume of air. Now we have already explained, in our 'Etudes sur les Vins,' that this is undesirable, and that it should be avoided in every case where it is not intended to affect the colour and taste of the wine, by a rapid process of oxidation, so as to impart to it an artificial appearance of age. This it is generally preferable to avoid, as it is most often productive of a peculiar taste, not

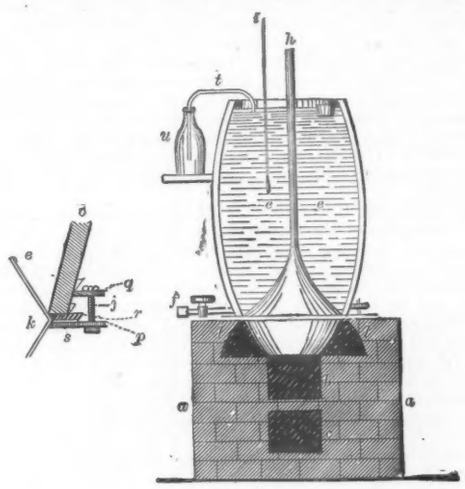


Fig. 5.

observable when the heating process is performed quickly and without exposure of the wine to atmospheric action. Heating, under the latter conditions, renders wine unalterable, without affecting its colour, or otherwise than by increasing its brilliancy or its taste, except by imparting to it additional briskness by the liberation of a greater or less volume of the carbonic acid gas which every wine contains.

"The complete filling of the apparatus may be provided for by fitting a china or tin tube to the upper part of the cask through which the superabundant wine may flow off into another receptacle.

"There are, however, certain conditions under which the wine may be exposed to a rapid process of oxygenation; these occur after racking. We need not speak of the action of the air on the wine as it runs through the india-rubber tubing (fig. 6).

"The rapidity with which the process of racking is effected renders the effects of atmospheric contact, either in the tubing or in the casks, of small importance; but, after a cask has been filled with hot wine and carefully tamped, a vacuum is formed in it by the progressive cooling and contraction of the wine, and a considerable volume of air will make its way in through the joints of the staves. The oxygen in this air is taken up by the wine and oxidizes it. M. Rossignol fills up his casks as they cool with hot wine. If it be desirable to avoid the possible access of air under these circumstances, the cask may be connected with another cask full of heated wine or of wine that has been subjected to the heating process. The connection is generally made with an india-rubber tube with metal pipes at each end, which are passed through holes in the bungs of the casks. When the casks have become filled, after cooling, the holes in the bungs are stopped with wooden spigots in the ordinary way.

"Casks so filled may be transported, either by sea or land, from one extremity of the globe to the other. When we add that the process is simple in its details, and inexpensive, it will be seen that it deserves to be adopted in every wine-producing country.

"Other advantages also accrue from its adoption. The wine may be allowed to rest without racking. It may be kept above ground.

"I am convinced that the chief benefit accruing from the use of underground cellarage, is the facilities which such arrangement affords for keeping wine at the low temperature generally requisite for the prevention of disease. Suppose the wine to be secured against adverse influences for an indefinite period, we may dispense with the cellarage. The same may be said of continual racking and clearing, which operations, in my opinion, are necessary in proportion as the wine is liable to alteration.

"I have strong hopes that the adoption of the aforesaid process of heating, may lead to important improvements in the old-fashioned methods of vinification."

M. Pasteur assumes that the wine may be run off hot into the casks, and allowed to cool there; that it will keep good without racking or clearing, and may be drawn as required for bottling or for immediate use; and he is convinced that the process will lead to improvements in the character of wine at present undreamt of. Were it deemed necessary to subject wine, which has been heated, to the processes of racking and clearing, it is

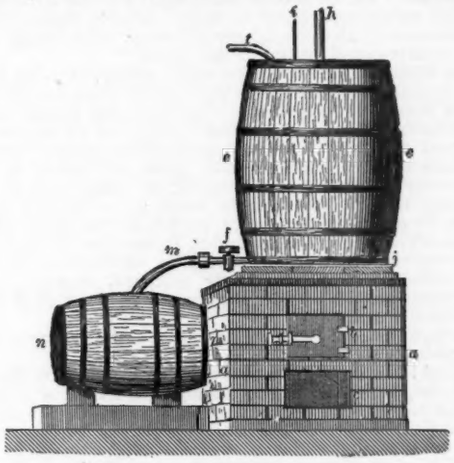


Fig. 6.

evident that as these processes necessitate a certain amount of exposure of the wine to the air, there would be a risk of inoculating the former with the noxious germs afloat in the latter, particularly with those of *mycoderma aceti* and *mycoderma vini*, and thus originating fresh changes. But the risk will be less, as the number of these germs present in the air is small, and those originally existing in the wine, if any such there were, have been destroyed.

But M. Pasteur considers it expedient that all such operations—including also the final distribution of the wine amongst the receptacles in which it is to remain—should be performed before it is subjected to "heating." For this reason he would dispense with the refrigerating portion of the apparatus, deeming it preferable to run the wine into the casks whilst at a temperature sufficiently high to destroy any organic germs which may exist in the latter.

In some experiments made by M. Rossignol, wine at a temperature of 140° Fahr. run off into a cold cask, showed a temperature of 136° to 138° Fahr. The results obtained by him after heating 500 casks of red and white wines from Orleans, Charente, and the Gironde, were extremely satisfactory. The wine remained bright and clear to the last *litre*, although the casks lasted on an average for six weeks' consumption each.

We have quoted rather minutely from M. Pasteur's work on this subject, as we believe his advice may prove of essential service to the growers of natural-made wines in our own country.

The improvement and maturing of full-bodied, liqueur-like wines by the heating process, does not demand the same care, especially in regard of the exclusion of the air, which, within certain limits, may even prove beneficial to them by its oxygenating influence.

We must not confound the application of heat to made wines, for the purposes above described, with the practice, adopted in some places, of employing it for the concentration of the *must* during vinification. The latter constitutes a process of wine-making of which we need not here speak.

The use of heat, and especially of *solar* heat, in ripening full-bodied wines, is of very ancient date. It was known to the Greeks and Romans. In the south of France, and particularly at Cette, where imitation Madeiras are made on an extensive scale, as also at Oporto and Lisbon, and in Spain, both the pipes and the wine itself are exposed for some time to solar action, to give a character of age to the wine in respect alike of colour and taste. In Madeira, and in some establishments in Lisbon, the wines, which for the most part are white and

strongly fortified, are heated in stoves to a temperature of 122° Fahr. for several months, by which they acquire greater robustness of constitution, and a certain taste approximating very closely to that imparted naturally to Madeira by long keeping. These stoves are vaulted rooms or buildings, capable of being closed hermetically when necessary, and heated by furnaces outside, the flues from which run round the inside of the walls. A thermometer, conveniently placed, indicates the internal temperature, so as to admit of its increase or abatement as required. In one establishment at Lisbon visited by the writer, the wine was heated in wooden casks holding two pipes each, with sufficient space to allow of the increase of volume during the process. The air in these unemployed portions of the casks supplied the oxygen requisite for certain chemical changes which improve strongly alcoholic, liqueur-like wines. Store-houses with glass roofs are employed with a like object.

The heating of wine in wooden casks, whether in stoves or by solar action, has one serious drawback—it entails a considerable loss of alcohol by evaporation. This does not happen when the wine is in bottles or jars, but in this case the increase of thickness necessary to secure impermeability renders these receptacles less accessible to solar action, particularly to the actinic rays, which exert so energetic an influence upon the colouring matter. Experiments, which the writer has made during the present year, have convinced him that white wines, moderately alcoholic and somewhat liqueur-like in character, when exposed to the sun for a week, in bottles not quite filled and carefully corked, are greatly improved, becoming clear and crystalline, with a golden tinge, which speaks well of their other qualifications.

We here quote M. Pasteur's directions for the performance of this operation :—

"Place the wine, in its natural state, or brandied to the desired strength, in glass bottles, adding, in the case of liqueur-wines, a proportion of sweet wine or sugar suitable to the degree of sweetness required. The bottles should not be completely filled, so that the air in them may furnish oxygen enough for the oxidation of the wine, and the development of those acids and ethers of which we have before spoken.

"When well-corked bottles are exposed to the full force of the sun's action, the effects are as follows:—

"The *obscure* heat accumulates rapidly, and the contents of the bottles, the air more particularly, are increased to a temperature exceeding 120° Fahr. The mycodermic germs perish as a natural consequence, and the wine becomes unchangeable. Acidification is no longer possible. After a few weeks the wine takes up oxygen and clears itself. It should then be decanted into bottles with the aid of a syphon, and without shaking. It will be found perfectly limpid, with all the most prominent characteristics of age, and notably *Madeira-ized*. It has moreover been rendered unalterable and incapable of forming a sediment."

These experiments may easily be repeated, and we commend them to the notice of our wine-growers, who, in practice, may be able to improve upon them, or to introduce certain modifications of them in accordance with local needs and the tastes of consumers.

To recapitulate what has been said above: the preservation of certain wines from various ulterior changes and maladies, to which they are more or less liable, and the amelioration and ripening of others, have incontestably been greatly advantaged by the practical adoption of the "heating" process.

In natural-made wines, both white and red, of ordinary alcoholic strength, good body, and rich in extractive matters, an artificial heating to 120° Fahr. or 140° Fahr., without exposure to the air, or for a brief space of time, never exceeding a few minutes, appears sufficient to dispel all noxious germs from the liquor and to enable it to withstand the effects, mechanical as well as climatic, of long journeys by sea and land.

In the case of full-bodied strong white wines, of a more or less liqueur-like character, heating, in glass jars not completely filled, and well stopped, by the rays of a burning sun, improves, clears, and ripens them, in a comparatively short time, which, at most, need not exceed one month.

Thin, weak, lymphatic wines are never worth heating, as they are almost always consumed before they have time to change. Further experiments in this matter are very desirable.

### 21.—The Effects of Cold upon Wine.

Extreme cold and excessive heat are equally obnoxious to organic life. As it is possible to destroy the vitality and capacity for action of the mycodermic germs, which are held to be the causes of fermentation, by subjecting them to a temperature of 112° Fahr., so also may the same results be obtained by reducing the temperature of the medium in which they are placed below the freezing point of water. Hence the idea of employing refrigeration as a means of preserving wine, by destroying the fermentative principles existing in it. Not only is it possible to get rid of the ferment in this manner, but also of much albuminous matter which is held in suspension by the wine to the detriment of its limpidity and flavour, and of some of the colouring matter and tartrates dissolved in it. A thorough refrigeration leads to the congelation of a portion of the water contained in the wine, separating it therefrom, and leaving the wine richer in alcohol. Consequently, refrigeration carried thus far, which requires the temperature to be reduced to 21° Fahr., is tantamount in its effects to a careful *clarification* combined with a moderate *brandying* of the wine, and these results are moreover secured without the introduction of any foreign element.

The phenomenon first observable during the refrigeratory process, and before the temperature has fallen to freezing point, is a certain turbidity of the liquor, caused by the congelation of the albuminous matters contained in it. These are precipitated, with the tartrates and a portion of the colouring principle, in the form of a heavy, viscous sediment. If the temperature be further lowered to 21° Fahr., the water begins to freeze in small spikelets and needle-like points, which attach themselves to the sides of the cask.

By decanting the wine under these circumstances, observing the precaution to use an aperture sufficiently small to arrest the passage of the ice-crystals, and afterwards keeping it for a few days at a temperature near freezing, to allow of the deposition of any residuary sediment, it will become clear, free from impurities, and fit to run off into cask or bottle. The wine is thus secured against morbific influences; it becomes fitted for carriage and exposure to variations of temperature; and these advantages are, in most cases, accompanied by a marked improvement in quality, but the process, like the application of heat, is not equally well adapted to every kind of wine. It may be advantageously used both with new and old wines, but it is more serviceable in the case of ordinary wines, poor in flavour and alcoholic strength, which are very apt to sicken, than it is with those of superior quality: to weak wines, which are not intended for keeping, it is never applied.

The climate of the greater portion of our wine-producing districts does not allow of the general adoption of this process on the spot. To apply it on an extended scale by turning to account any natural decrease of atmospheric temperature would require a severe winter, with days when the thermometer should stand at 21° Fahr., followed by calm, still nights, when it should fall to 15° Fahr.; a state of affairs seldom met with in our most elevated mountain districts. Our only resource, therefore, is the application of freezing mixtures, such as ice and salt, in refrigerating tubes. In Burgundy, where the process is much used, and where it is rarely possible to turn the temperature of the air to account, artificial congelation is effected with the aid of a very primitive apparatus.

A refrigerating tube of tinfoil, similar in shape to those used in ice-boxes, and provided with a close-fitting lid, is plunged into a barrel of suitable capacity full of wine. These refrigerators generally hold about a hectolitre (22 galls. English). Within the refrigerator is placed a mixture of ice and salt. After standing for a few hours the melted ice is run off through a stop cock at the bottom and a fresh supply of the mixture is introduced in the tube. When the congelation of the wine has been carried to the desired point, the refrigerator is withdrawn and the wine racked off into the casks, where it is to stand, and deposits its sediment.

It is desirable that the wine should remain for some little time exposed to the cold, so as to secure its limpidity. It is then again racked into the casks in which it is to remain. It is advisable, before exposing the wine to congelation, to keep it as cold as possible, so as to avoid a sudden change of temperature, as well as to shorten the duration of the final operation. Under favourable circumstances, which we may be excused from enlarging upon here, it is possible, during cold and calm winter-days, to treat large quantities of wine in this manner, thereby acquiring for it perfect limpidity, greater alcoholic strength, and increased power of resisting the effects of sea-carriage and foreign climates.

### Conclusion.

In the first portion of the present work we have laid down rules for the guidance of vine-growers in the fabrication of good, sound, wholesome, natural-made wine, in accordance, be it understood, with the principles which we ourselves adopt in practice. In the performance of this task we have been encouraged by the hope of thus conferring benefit upon home-consumers, and contributing to the extension of our export trade in wine. If the rules we have given be closely adhered to, we do not hesitate to assert that the results of the manufacture will be a well-made wine.

So long as we restrict ourselves to the production of wines of this character we shall have less need of the second portion of this treatise, which deals with the nosography of wine, as we have seen that well-made wine sickens rarely and only by age.

The difficulty is to ensure its being well made, and this difficulty is not inherent to the processes themselves, but rather to the methods of applying them. There are many diversities of mental capacity. Some men are active, intelligent, and energetic, quick of apprehension, desirous of improvement; others are dull, prejudiced, and indolent, upholders of old-fashioned notions through sheer obstinacy and stupidity; and amongst the latter are not a few growers and makers of wine, whose produce is in excellent keeping with their peculiar views. But many circumstances, uncontrollable by the skill and effort of man, exert a detrimental influence over the results of his industry. Wine is no exception to the rule. With every care the germs of disturbance will yet become incorporated with it. We must be prepared to meet the difficulties thence arising. However well made wine may be, it is nevertheless essential to know and understand the maladies which *may* affect it.

There can be no question as to the importance of good wine-making to the production of good wine. But, if disease threatens, we require to know how to arrest its progress; if it has already appeared, how to counteract its effects.

For the accomplishment of this difficult task, all œnological writers agree in recommending the adoption of certain preventive measures.

Of these preventives, some are simple hygienic precautions, such are *racking*, *clarification*, keeping the casks filled, and above all, cleanliness. Others come within the category of expedients, and two of them are of great value,—viz., brandying, which besides its costliness has the additional disadvantage of changing the character of the wine, and is therefore opposed to our views respecting the fabrication of genuine natural-made, alimentary wines; and the heating process, which we believe to be the most efficacious, and which allows the amelioration and strengthening of the wine to be combined with the retention of its natural qualities. For this process we anticipate a great future, possibly even the regeneration of this branch of our commerce through its agency, if our wine-growers will only make up their minds to devote their energies to the production of pure and sound wine by the most approved and safest methods of manufacture.

## *Chemistry applied to the Arts, Metallurgy, Chemical Manufactures, and Allied Subjects.*

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF CHEMICAL SOCIETIES, &c.

### § 1. *Acids, Alkalies, and Salts.*

**MANUFACTURE of Soda.**—A. R. ARROTT manufactures soda carbonate as follows:—Triphosphate of soda is carbonated so as to convert one equivalent of soda into carbonate of soda. The carbonate of soda is then separated from the diphosphate left. This diphosphate is then again transformed into triphosphate and is again carbonated, and so on continuously.

The reconversion of the diphosphate is effected by mixing it with one equivalent or rather more of common salt (a small portion of common salt being volatilized during the process), and fusing this mixture in a reverberatory or other suitable furnace, admitting steam at the same time if necessary; hydrochloric acid is evolved, and triphosphate of soda formed.

When the decomposition is complete, the triphosphate is removed from the furnace dissolved in water, and exposed to the action of carbonic acid, by which the third equivalent of soda is converted into carbonate of soda. Or, bicarbonate of soda is added in such quantity that the second equivalent of carbonic acid will convert the third equivalent of soda in the triphosphate into carbonate of soda. The solution is then evaporated and allowed to cool, when the sodic diphosphate crystallizes out, whilst the carbonate remains in solution. The concentration of the liquid should be such that on cooling crystallization begins at about 110° Fahr.

**Pyrites as a Source of, and Substitute for, Sulphur.**—C. R. A. WRIGHT states that the use of pyrites, copper pyrites, and analogous minerals, such as zinc blende, in the manufacture of the different "vitriols" (green vitriol or ferrous sulphate, blue vitriol or cupric sulphate, and white vitriol or zinc sulphate), is of considerable antiquity, these salts having been known from an early period as being produced by the natural or artificial oxidation of these sulphur-containing minerals; and the use of copper pyrites, galena, and zinc blende as sources respectively of metallic copper, lead, and zinc, and other alloys, also dates from a comparatively early epoch. Moreover, it has long been known that when pyrites is heated in open vessels so as to prevent free access of air, sulphur dioxide is formed, whilst more recently it has been found that when the heating is effected in closed vessels, sulphur is expelled as such, and may be collected by means of suitable condensing arrangements. It is, indeed, not improbable that some at least of the sulphur found in the free state in volcanic districts is actually derived from this source in this way, although a considerable portion of such natural sulphur is probably formed by the mutual reaction of gaseous sulphuretted hydrogen and sulphur dioxide, water and free sulphur being produced; advantage has been taken of this change to obtain sulphur from pyrites commercially, one portion of the mineral being heated in contact with air so as to form sulphur dioxide by the combustion of the sulphur present, another being so treated as to give rise to sulphuretted hydrogen.

As far back as the first part of the last century, processes for the extraction of free sulphur from pyrites and analogous minerals appear to have been worked in this country. The extraction of free sulphur from pyrites in this way is still practised to some extent, the apparatus employed being very simple. The ore is broken into small fragments the size of nuts, and is then piled up inside a cylindrical roasting vessel capable of holding fifty to sixty tons of material; this vessel is simply a circular wall of masonry enclosing a level floor, along which pass four flues meeting in the centre in the form of a cross. Through these the requisite supply of air enters, the floor communicating with the flues by openings here and there; the heap of ore is covered over with earth and turf, an opening being left for an exit pipe, along which the vapours pass to a long condensing flue. The mass is lighted at the openings of the four flues arranged as a cross, and these openings are then partially closed; the heat generated by the combustion of a portion of the sulphur present serves to expel the rest, most of which is condensed in the main condensing flue. The operation usually lasts about six weeks, and the amount of sulphur collected is but small as compared with the quantity that is burnt and escapes as sulphurous oxide.

When heated in a closed vessel, iron disulphide parts with about ⅓ of its sulphur in the free state, the product being a kind of "magnetic pyrites." Tubular clay retorts, arranged in rows and heated simultaneously by a furnace, are sometimes employed for this purpose; but only about a quarter of the sulphur present can be thus obtained with safety, as the residue is readily fusible, and cannot easily be removed from the retort if once fluxed.

The chief commercial use of pyrites, however, so far as its contained sulphur is concerned, depends not on the extraction from the mineral of free sulphur, but on its transformation into compounds obtainable at a dearer rate from free sulphur; *i. e.* on the use of pyrites, not as a source of sulphur, but as a cheap substitute for that substance. Several of these applications are of considerable antiquity, *e. g.* the formation of green, blue and white vitriol, and the production from green vitriol of Nordhausen sulphuric acid by dehydration and distillation. The manufacture of alum from alum schist (an argillaceous rock containing a good deal of yellow iron pyrites disseminated through it) also depends on the same process. During the oxidation of pyrites, two proportions of sulphuric acid and one of ferrous oxide may be regarded as formed; of the sulphuric acid half therefore becomes converted into ferrous sulphate, whilst the other half forms sulphate of alumina by attacking the aluminous mineral in which the pyrites is imbedded. By dissolving the product obtained by gently roasting, or calcining alum schist in water, a solution of aluminium and iron sulphates is produced; and by adding to this solution chloride of potassium or ammonium, double decomposition takes place between the alkaline salt and the iron sulphate, iron chloride being formed, and potassium or ammonium sulphate, which crystallizes out along with the aluminium sulphate in the form of either potassium or ammonium alum; or sulphate of potassium or ammonium may be employed in lieu of chloride.

Longmaid's well-known process for the preparation of sulphate of soda, by heating together a mixture of pyrites and common salt, partly depends on the same principles; the sulphur of the pyrites takes up oxygen, and the two unite with the sodium of the salt; simultaneously ferric chloride and its decomposition products, formed by the action of air and moisture, ferric oxide,

hydrochloric acid, chlorine, &c. are found, the latter two escaping as gases. This process, it may be noticed in passing, is virtually the parent of a number of other methods since proposed for the manufacture of sulphate of soda, chloride of copper, and chlorine. The process of Henderson for the extraction of copper from pyrites; the recent method of Robinson and Hargreaves for the manufacture of sulphate of soda without the use of vitriol; and, to some extent, Deacon's chlorine process, may all be regarded as deducible from Longmaid's process, the essential reactions characteristic of these various methods taking place in their common parent-process.

The most important use of pyrites, however, as a substitute for sulphur, consists in its employment on the large scale as a means of producing sulphur dioxide for the manufacture of sulphites, bisulphites, sulphates, antichlors, disinfectants, &c.; and principally for the production of sulphuric acid and its derivatives. *Extract from a Paper read before the Society of Arts.*

**Utilization of Blast-Furnace Slags.**—As far back as 1822 RANCOURT DE CHARLEVILLE mentioned that hydraulic cements can be made from slag: most slags resemble in their composition those double hydrosilicates of lime and alumina, which (mixed and burnt with lime) yield hydraulic cement. ELSNER analyzed two specimens of slags from the Gleivitz works in Upper Silesia and found them to consist of:

| | (1.) | (2.) |
|---|---|---|
| Silica | 40·12 | 40·44 |
| Alumina | 15·37 | 15·38 |
| Lime | 36·02 | 13·10 |
| Suboxide of manganese | 5·80 | 4·40 |
| " " iron | 1·25 | 1·63 |
| Potash | 2·25 | 2·07 |
| Sulphur | 0·70 | 0·76 |

Still better fitted for the preparation are the slags from some French furnaces, as seen by the following analytical figures :—

| | (1.) | (2.) | (3.) | (4.) |
|---|---|---|---|---|
| Silica | 50·00 | 55·20 | 59·42 | 49·00 |
| Alumina | 19·60 | 19·20 | 14·94 | 21·80 |
| Lime | 26·40 | 19·20 | 19·79 | 24·00 |
| Magnesia | 2·00 | 1·40 | 0·11 | traces. |
| Oxide of iron | 2·40 | 3·40 | 6·03 | 2·10 |
| Oxide of manganese | — | 1·40 | traces. | 0·60 |

All these slags yield on treatment with hydrochloric acid silica as a jelly, which reaction serves also as a test for their applicability for cement.

BODMER & CO., of Hammersmith, manufacture bricks from slags; these are cheaper and possess much more durability than ordinary clay bricks. *Dingler's Polyt. Jour. cviii.* 57.

**Nitrate of Silver.**—R. PALM obtains pure silver nitrate from silver alloyed with copper by the following process. The alloy is dissolved in nitric acid, the solution concentrated to the consistency of syrup, and mixed with strong nitric acid. The silver nitrate crystals precipitate on the addition of the acid, whilst the copper is left in solution. Repeated washing of the crystals with concentrated nitric acid frees them from every trace of copper. *Polyt. Centralbl.* 1873.

## § 2. *Metallurgy.*

**Foreign Iron Ores in Westphalia.**—Ores from Mokta-el-Hadid (Algiers), the isle of Elba, Spain, Servia and Sweden, are worked up in the Phœnix Works in Westphalia, and are distinguished by low percentage of phosphorus, as seen by the following analytical figures :—

| | | | |
|---|---|---|---|
| Ore from | Mokta-el-Hadid | 0·013—00·3 | per cent. of phosphorus. |
| " | Elba | 0·008 | " " |
| " | Bilboa, Spain | 0·06 | " " |
| " | Servia | 0·025 | " " |
| " | Sweden | 0·04 | " " |

*Chem. Centralbl.* 1873. 223.

**Purifying of Pig Iron.**—SCHEERER states that a mixture of equal weights of chloride of calcium and chloride of sodium (common salt) is a powerful dephosphorizing reagent. Chloride of calcium alone is less efficient and much more expensive, and common salt alone volatilizes in the puddling furnace, and is useless as a dephosphorizing reagent. The calcic chloride should be made from pure limestone. The compound must be brought into as intimate contact with the mass of iron to be puddled as possible, and should therefore be added in portions of about 2lbs. at a time, kept in water-tight paper packages or cartridges. The molten mass to be rabbled at each addition to the reagent, or the whole quantity of reagent required, may be put on at once on the sole of the furnace, and the pig metal melted upon it, and then active and careful rabbling carried on. This rabbling is an essential condition to the complete removal of the phosphorus. The puddling process proper is in no way changed.

The reagent is applied in converters for producing steel in a strictly analogous manner. The quantity of the compound reagent to be added to each charge is about three times the weight of phosphorus known to be in the pig metal to be puddled or converted. *Dingler's Pol. Journal.*

**Dormoy's Puddling Apparatus.**—This apparatus, considerably less expensive than Danks' puddling furnace, consists of a rotating rabble which is thrown into rapid revolution by steam-power, while its direction is readily controlled by the hand of the puddler.

A revolving shaft above the furnace carries a belt which is connected with another pulley below. This pulley is secured to the outer end of the rabble, which is thus caused to rotate somewhat in the fashion of the well-known revolving brush used by the hair-dresser. By means of a handle jointed to the lower pulley, the puddler readily directs the movements of the rabble. From 300 to 500 revolutions per minute are made by the tool when white pig iron is treated, and from 800 to 1,000 for grey pig. The point of the rabble in the furnace carries a disk which agitates the molten metal, and effectually renews the surface exposed to the air.

When the iron "comes to nature" another rabble is used, having, in place of the disk, a short twisted point. Dormoy's method has been successfully employed in Austria and France. It is said that the yield of wrought iron is increased by at least 30 per cent., while the consumption of fuel is proportionately diminished; that the puddler is relieved of much of his fatigue, although the number of heats in a given time is considerably increased; and, finally, that the phosphorus and sulphur are removed from the metal to such an extent that excellent iron may be obtained from inferior brands of pig. *Polytech. Centralb.* 1873.

**Hardening Steel.**—It is not generally known that steel can be made so hard that it will pierce any known substance but a diamond. Many jewellers and lapidaries have great trouble in getting the points of their drills hard enough to pierce an amethyst. For the benefit of miners and others using drills that require a hard point, the following manner of manipulation may be recommended. The drills should be held, if small, by hot pincers or tongs, while tempering. First heat the tool to a white heat, and then press it into a stick of sealing-wax; leave it but a second there, and then stick it into the wax in another place. This operation is rapidly repeated until the graver is too cool to enter the wax. In turning or drilling, the tool should be moistened with oil of turpentine.

**Spanish and Portuguese Pyrites as a Copper Ore.**—Messrs. MIGUEL, IGLESIAS and SONS state that the average of 3,000 assays of the pyrites imported from Huelva, Pomaron, and other Spanish and Portuguese ports of the Guadiana, is :

Copper . . . 2·70 per cent.

All ore raised at Tharsis (besides other kinds) is shipped at Huelva; in 1873, 250,000 tons of Tharsis and other ores were exported from that port, and over 20,000 tons from the Guadiana, chiefly from the Portuguese port of Pomaron.

The importations of pyrites from Norway are of great importance, probably equalling in amount those from Belgium, Cornwall, Wicklow, Westphalia, Pomerania and Sweden, all put together. *Journal of the Society of Arts.*

**Welding of Copper.**—P. RUST employs a mixture composed of 358 parts of phosphate of soda and 124 parts of boracic acid. The powder is to be applied when the metal is at a dull red heat; it is then brought to a cherry-red and at once hammered. As the metal is very apt to soften when exposed to a high degree of heat, a wooden hammer is recommended. All carbonaceous matters are to be carefully removed from the surfaces to be joined, since the success of the operation depends on the formation of a very fusible phosphate of copper, which would be reduced by the carbon to the state of a phosphate. The phosphate of copper dissolves a thin film of oxide on the surfaces of the metal, keeping these clean and in a condition to weld. *Journal of the Franklin Institute.*

**Impurities in Lead.**—Ordinary commercial lead contains many impurities, such as sulphur, iron, tin, antimony, and copper.

Impure lead is known by being whiter and less soft than the pure article, which readily stains the hands, linen, &c. The impurities commonly found are injurious for technical applications, especially for white lead making. Pure lead melts at 330° to 335° C. It is brittle when exposed to a temperature a little below its melting point, and volatile at a white heat. *Chem. Centralblatt.*

**Extraction of Silver from Burnt Pyrites.**—C. R. A. WRIGHT states that some varieties of pyrites contain a notable amount of silver, though insufficient to render its extraction profitable as a separate business. Most of this valuable metal can, however, be extracted by the following modification of Henderson's copper extracting process, due to Claudet. The whole of the common salt used in the roasting process is not converted into sulphate, some remaining unaltered. Thus the aqueous extract first obtained is brine, containing copper, iron, and sodium salts, &c., dissolved therein. Now the process that converts the copper compounds present in the burnt ore, also transforms any silver present into chloride, which chloride is almost wholly dissolved out from the roasted mass by the agency of the brine, silver chloride being much more soluble in this menstruum than in plain water. Silver iodide, however, is very much less soluble in brine than is silver chloride. Hence, by adding to the aqueous liquors first obtained (before separation of the metallic copper) a soluble iodide, a precipitate is formed containing most of the silver originally present in the pyrites used in the first instance.

In practically working this process the liquors containing the silver, *i.e.* those obtained by lixiviation with water before treatment with acid, are run into a wooden settling tank. When the suspended matter has deposited, the clear liquors are drawn off into another tank, and a solution of iodide of potassium added (crude iodide solution from pulp may be used), and the whole well mixed. After forty-eight hours' rest, a deposit is thrown down consisting chiefly of sulphate of lead, iodide of silver, and some copper compounds, and also containing a small quantity of gold. The clear liquor is run off and precipitated by iron to extract the copper. The deposit is washed with water, and then with dilute hydrochloric acid to remove the copper compounds, and is then digested with metallic zinc, whereby the silver iodide is decomposed, metallic silver being set free and soluble zinc iodide formed. The solution of this latter salt is used over again to precipitate a fresh batch as iodide. Most of the lead sulphate is also decomposed by the zinc, so that the resulting mass, when dry, has about the following composition (Claudet) :—

| | |
|---|---|
| Silver | 5·95 |
| Gold | 0·06 |
| Lead | 62·28 |
| Copper | 0·60 |
| Zinc oxide | 15·46 |
| Iron oxide | 1·50 |
| Lime | 1·10 |
| Sulphuric acid | 7·68 |
| Insoluble matter | 1·75 |
| Oxygen, loss, &c. | 3·62 |
| | 100·00 |

From this mass the silver and the gold are separated by the ordinary processes in use in the refining of these materials.

Usually the deposit of silver iodide, &c., is not removed at once from the depositing tank, but is allowed to remain in while successive batches are worked off, whereby labour is saved, the deposit being only treated with zinc, &c., at intervals, as it accumulates.

The cupriferous pyrites of Spain and Portugal contain from 0·002 to 0·003 per cent. of gold and silver; from 16,300 tons of such ore, after burning off most of the sulphur in the vitriol works, 739 lbs. of silver and 7 lbs. of gold were extracted at Widnes, or about 340 grains (¾ oz. avoirdupois) per ton. The cost of preparation of this, including 300 lbs. of iodine consumed during the operation, was £416, leaving a clear gain of £3,250 (Claudet). *Paper read before the Society of Arts.*

**Toughening Brittle Gold.**—The most effectual process yet discovered to toughen brittle gold is by simply passing chlorine through the molten metal. By following this method a saving of one-half in the amount of gold usually set aside each year as unfit for working has been effected. *Chem. Centralbl.*

**Pyrites as a Silver and Gold Ore.**—MESSRS. MIGUEL IGLESIAS & SONS state that although the cupriferous pyrites imported into this country from Huelva and the Spanish and Portuguese ports of the Guadiana (chiefly from Pomaron) is very uniform in composition as regards iron, copper and sulphur, yet the silver value of ores from different deposits varies very considerably, the average of one ore being from ½ to ¾ of an ounce of silver per ton of ore, and the average of another being from 3½ to 4 ounces, in each case together with traces of gold. Since the fact has been recognized that these metals can be profitably extracted, many thousand ounces of silver have been recovered in addition to gold enough to repay the cost of working; and as the plant required is most inexpensive, it is greatly to be regretted that the process is not universally adopted. It is certain that during the last ten years silver and gold of a net value of at least a million sterling has been allowed to run away in the waste liquors from metal-extracting processes. *Journal of the Society of Arts.*

**Preparation of Metallic Potassium.**—DOLBEAR gives the following method: Strong solution of caustic potash is treated with sulphuretted hydrogen, and the solution of potassic sulphids thus formed is evaporated to dryness. The solid mass is then mixed with somewhat more than its bulk of iron filings, and subjected to distillation, the product of distillation being collected under petroleum. *Polytech. Centralbl.*

## § 3. *Dyeing, Calico Printing, Tanning, Bleaching, and allied subjects.*

**Aniline Oils.**—F. VERSMANN states that the following impurities may be present in commercial aniline oils: (1) Undecomposed benzol, toluol and other hydrocarbons; (2) Products formed by the deoxidation of higher nitro compounds; and (3) undecomposed nitrobenzol and other higher nitro-compounds.

Commercial or impure aniline is sold under the name of *aniline oil*, to distinguish it from the *chemically pure* article. Such commercial aniline, submitted to fractional distillation, gives generally the following products, viz.:—

| Name | Per cent. | Boiling Point. Centigrade. | Fahrenheit. |
|---|---|---|---|
| Pure Aniline. | 60 to 65 | 180 to 185 | 356 to 365 |
| Mixtures of Aniline and Toluidine. | 18 to 22 | 185 to 192 | 365 to 378 |
| Toluidine. | 8 | 192 to 198 | 378 to 388 |
| Xylidine, Cumidine, etc. | 4 to 6 | above 198 | above 388 |

Hartmann submitted samples of commercial aniline to fractional distillation and made separate practical experiments in printing with all the various products. The three samples had a specific gravity of 2°, 3°, and 2.25° Bé. respectively, and gave the following quantities, boiling at the different temperatures indicated, viz.:—

| No. I. | | No. II. | | No. III. | | Boiling Point. | |
|---|---|---|---|---|---|---|---|
| Per cent. | Specific gravity. | Per cent. | Specific gravity. | Per cent. | Specific gravity. | Centigrade. | Fahrenheit. |
| 6 | ... | 12 | ... | 8 | ... | 180° | 356° |
| 62 | 2.75° Bé | 50 | 3·4° | 54 | 3.° Bé | 180° to 185° | 356° to 365° |
| 20 | 1.60° | 24 | 2.1°Bé | 22 | 1.° | 185° to 192° | 365° to 378° |
| 10 | 60° | 6 | 1.0° | 10 | .9° | 192° to 198° | 378° to 388° |
| 2 | | 8 | 5° | 6 | .5° | 198° to 215° | 388° to 419° |

These three samples, fair specimens of the commercial article, contain only 62, 50 and 54 per cent. of pure aniline.

To test aniline oils several methods may be followed.

The specific gravity gives some indication as to the quality. Any aniline oil of 2 to 3° Bé = 3 to 4° Tw., is good if not fraudulently adulterated; if heavier, it generally contains undecomposed nitrobenzol, if lighter, it contains too much toluidine, which interferes with the development of aniline black and is often the cause of much trouble in printing.

*Fractional distillation* gives a more reliable result; the percentage of aniline distilling between 180° and 185°C. represents the true value of the article.

*Concentrated Sulphuric Acid*, diluted with three times its weight of water, is also a good test. About one part of aniline is mixed with at least three parts of the dilute acid, a thick paste of sulphate of aniline is formed, more water is added to dissolve the salt, when any tarry impurities and also nitrobenzol collect at the top.

*Comparative experiments in printing black* are the most perfect tests, and cannot be too strongly recommended. Four pounds of Coupier's pure aniline has been found to be the smallest quantity to produce a pretty good black with the following mixture. In testing a sample, it is as well to take 4 lbs. of the same and gradually increase the quantity, till a really good black has been produced; the more aniline is required the more it loses in value.

The following mixtures may be used:—

No. 1.

| | |
|---|---|
| Thickening | 9 gills. |
| Chlorate of potash | 5 lbs. |

| | |
|---|---|
| Chloride of ammonia | 5 lbs. |
| Sulphate of copper | 5 lbs. |
| Aniline oil | 6½ lbs. |
| Tartaric acid | 7½ lbs. |

No. 2.

| | |
|---|---|
| Chlorate of potash | 3 lbs. |
| Chloride of aniline | 7½ lbs. |
| Sulphate of copper | 3 lbs. |
| Chloride of copper solution 57 Bé=88°Tw. | 6 lbs. |
| Water | 10 gills. |

Thickening.

*Chloride of Aniline* or *Aniline salt* is prepared by mixing 8 measures of aniline oil and 9 measures of hydrochloric acid at 20°Bé=32°Tw. and evaporating the mixture in a sandbath till white vapours begin to go off; after cooling, a solid, brittle mass is left, which is broken up and bottled for sale. *"Aniline Black." By F. Versmann, Ph.D.*

**Indulin Blue.**—C. PFUNDHELLER gives the following prescription for dyeing with indulin:—The blue is first dissolved by rubbing up in a little water and then boiling in from 50 to 100 parts of water. In preparing the bath borax or soda is added, to make it alkaline; the colouring matter and the wool must be heated to 100° C. (212° Fahr.), and the boiling must be continued until a sample, taken out and boiled in water acidulated with sulphuric acid, exhibits the desired shade. The entire mass of wool is then to be taken from the alkaline bath, drained off, washed, and treated in a boiling-water bath with sulphuric acid and chloride of tin, in which the blue colour, as shown in the sample, will become developed. After some further boiling the operation will be completed. *Polyt. Centralbl.* 1872.

**Composition of Madder and Madder Colours.**—F. VERSMANN states that madder contains chiefly two colouring principles, *purpurine* and *alizarine;* these colours are not ready formed in the roots, but are products of decomposition of another substance, which has no colouring property; according to Decaisne's microscopical investigations, the fresh roots are filled with a yellow transparent fluid, which turns red under the influence of the air after the cells are broken.

The analysis of madder root shows that it leaves about 20 per cent. of dry substance, but the commercial article contains from 16 to 18 per cent. of moisture.

100 parts of the dry root contain:

| | |
|---|---|
| Substance soluble in cold water | 55·0 parts. |
| „ „ „ boiling water (including most of the colour) | 3·0 „ |
| Substance soluble in alcohol | 1·5 „ |
| Fibrous matter | 40·5 „ |

Among the substances soluble in water are gum, sugar, pectic acid and a yellow colouring matter, discovered by Kuhlmann in 1824, and called by him *Xanthine*, but which has not found practical application. The solutions in boiling water and alcohol contain chiefly resin and colouring matter.

The amount of sugar is considerable, some 10 or 15 per cent., which is converted by some French manufacturers into alcohol; madder is washed with water, the washings are allowed to ferment and the alcohol thus formed is distilled off; a ton of madder gives about 30 gallons of alcohol, which has a peculiar, unpleasant flavour, but it is well adapted for technical purposes.

Schutzenberger gives the following analysis of madder and its derivatives:

| Name of substance. | Inorganic substance or ashes, of which | Soluble in water, chiefly chloride of potassium, little carbonate of lime. | Insoluble in water, viz. | Silica. | Carbonate of lime. | Phosphate of lime. | Sulphate of lime. |
|---|---|---|---|---|---|---|---|
| Avignon madder | 13·63 | 3·00 | 10·63 | 2·90 | 5·72 | 1·93 | |
| Flowers of madder (Fleur de garance) | 12·63 | 0·77 | 11·85 | 3·28 | 6·24 | 1·70 | |
| Garancine | 17·75 | | 17·75 | 10·20 | 4·48 | 1·90 | 1·06 |
| Alizarine, commercial | 11·80 | | 8·14 | 2·58 | 1·03 | | |
| Madder carmine | 12·00 | | 12·00 | 4·50 | 5·50 | trace | 1·95 |

To prepare garancine, madder is boiled with sulphuric acid for some hours, the liquid is separated by filtration, the residue washed with weak solution of carbonate of soda to neutralize any acid, pressed and dried; 100 parts of madder yield 35 to 37 parts of garancine in the form of a fine powder of a light brown colour, having four times the tinctorial power of madder.

Alizarine and purpurine are prepared as follows:—Large wooden tanks with false bottoms are charged with 600 lbs. of ground madder and 1000 gallons of sulphurous acid water at a time. The mixture is allowed to stand for 12 hours, when the liquid is drawn off through a tap at the bottom; the residue is washed with another 150 gallons of acid water and the liquid run off after a couple of hours and mixed with the first; these liquids are run into the purpurine vats, holding about 1500 gallons each; 3 per cent. of sulphuric acid is then added, and the whole heated by steam to about 35° to 40° C., when purpurine soon begins to separate in large flakes; after 12 hours' standing the purpurine is collected on a filter, washed with water, and dried; the coloured liquid is drawn off into the alizarine vats, then heated to the boiling point, when an impure substance, called green alizarine, separates, which is collected similarly to the purpurine.

100 parts of Alsatian madder yield ½ to ¾ per cent. of purpurine, which is about 20 times as powerful as madder, and 3 per cent. of alizarine, about 20 times as strong as madder. The madder residue is not fully exhausted, but is treated with the acid washings from alizarine and dried; the products, about one-third of the original substance, is similar to garancine, but is only half as strong. But even then another preparation is obtained from the washings of the last operation; these are kept for some time, when a brownish alizarine separates, which is collected and sold as an extract, being from 1 to 1¼ per cent. of the madder first taken.

By treating green alizarine with alcohol, 20 to 30 per cent. of yellow alizarine is extracted; rectified petroleum or schist oil is, however, a cheaper agent than alcohol.

One part of green alizarine is boiled with 15 to 20 parts of petroleum, boiling at about 150°; when the suspended green matter has separated by standing a little, the hot solution is decanted; some alizarine separates on cooling; the whole is extracted by shaking up with caustic soda lye as soon as the temperature has fallen to about 100°; from the solution of alizarate of sodium thus produced, the alizarine is precipitated as yellow flakes by means of sulphuric acid; these are well washed till free from acid, and dried.

Another process, which has been followed very extensively and for many years, is based upon Leitenberger's observation that the two colouring principles are separately soluble in water at different temperatures, viz., that purpurine is soluble in water at from 25° to 55° C., while alizarine requires a very high temperature. Leitenberger, therefore, repeatedly extracts madder with water heated by steam to a temperature not exceeding 55° C., and precipitates the purpurine thus dissolved by lime or baryta; the precipitate is then decomposed by hydrochloric acid, when the purpurine separates; it is then washed and dried.

The madder is afterwards dried and fully exhausted with boiling wood-spirit, which dissolves the alizarine; this is separated nearly chemically pure, by pouring the solution in water. Leitenberger obtains thus 2 to 3 per cent. of purpurine, and 4 to 4½ per cent. of alizarine; he also claims great superiority for his preparations over other products, which he has expressed in the following numbers, as quantities required to produce the same effect upon equal pieces of cloth:—

| | |
|---|---|
| Leitenberger's alizarine, | 2 |
| Garancine, | 20 |
| Madder, | 70 to 80 |

Paraf proposes to prepare purpurine and alizarine by dissolving out the wood, fibre, &c. by a solvent which does not act on the dyestuffs, such as ammoniacal copper solution.

As all madder preparations have frequently been adulterated, it may be useful to state a simple method of testing their purity. Pernod divides the dyewoods and other substances which may be used for this purpose into two classes, namely, those which give coloured combinations with alumina and iron, such as brazilwood, logwood, fustic, &c., and those which contain tannic acid, but no colouring principles, or at least very little, such as several barks, galls, sumach, &c. The last do not produce any coloured combination with alumina, while they give black or brown precipitates with oxide of iron.

To detect even small quantities of any of the substances belonging to the first division, the following test is given:—Take a piece of white paper about four inches square, dip it into an acid solution of chloride of tin, place it on a glass or porcelain plate, and sprinkle a little of the finely powdered substance over it. In about half an hour, any adulteration will show thus: brazilwood carmine red points; logwood purple spots; fustic yellow coloration, while with pure madder only a faint yellow colour will appear. The same method is followed in looking for substances of the second class, merely substituting a solution of sulphate of iron for the chloride of tin. Any substance containing tannin will produce blueish-black spots, which increase in intensity the more the sample is adulterated. One part of any of such

fraudulent admixtures in a thousand parts of madder may thus readily be detected. "*Alizarine.*" *By F. Versmann, Ph.D., New York.*

**Calico-Printing with Artificial Alizarine.**—F. VERSMANN gives the following receipts :—

REDS.

| | | |
|---|---|---|
| 5 lbs. | Alizarine paste | 10 per cent. |
| 16 lbs. | Thickening | |
| 1 lb. | Acetate of alumina | 10 Bé=15°Tw. |
| ½ lb. | Acetate of lime | 16 Bé=25°Tw. |

PINKS.

The same, diluted with 2 or 3 parts of thickening.

For double printing, when deep red is printed on first, the goods must be steamed one hour before the second printing takes place. After the second printing, the goods must again be steamed one hour, and hung up to air for 24 hours ; they are then passed through one of the following baths at a temperature of 120° to 140°F., remaining in the bath not longer than 1 to 1½ minute.

| | |
|---|---|
| Water | 250 gallons. |
| Chalk | 60 lbs. |
| Tin Crystals | 3 lbs. |

Or

| | |
|---|---|
| Water | 250 gallons. |
| Chalk | 40 lbs. |
| Arseniate of Soda | 10 lbs. |

The goods are then washed and brightened as follows : take for 10 pieces of 50 yards each :—

| | | |
|---|---|---|
| 1st Soaping at | 120°F. | 3 lbs. of Soap. ¼ lb. Tin Crystals. |
| 2nd „ | at 160°F. | 3 lbs. of Soap. |
| 3rd „ | at 175°F. | 3 lbs. of Soap. |

Wash between each soaping.

RED FOR MOSAICS (MILLE-FLEURS).

| | |
|---|---|
| Alizarine paste, 10 per cent. | 8 lbs. |
| Thickening | 10 quarts. |
| Nitrate of Alumina, 15°Bé=23°Tw. | 9½ ounces. |
| Acetate of Alumina, 10°Bé=15°Tw. | 19 ounces. |
| Acetate of Lime, 16°Bé=25°Tw. | 13 ounces. |

VERY DEEP RED.

| | |
|---|---|
| Alizarine paste, 10 per cent. | 10 lbs. |
| Thickening | 10 quarts. |
| Nitrate of Alumina, 15°Bé=23°Tw. | 13 ounces. |
| Acetate of Alumina, 10°Bé=15°Tw. | 19 ounces. |
| Acetate of Lime, 16°Bé=25°Tw. | 16 ounces. |

ANOTHER RED WITHOUT OIL.

| | |
|---|---|
| Alizarine paste, 10 per cent. | 8½ lbs. |
| Acetic Acid, 8°Bé=12°Tw. | 9½ lbs. |
| Flour | 3½ lbs. |
| Water | 5 pints. |

Boil well and stir till cold, then add—

| | |
|---|---|
| 1st Acetate of Lime, | 18°Bé=29°Tw. |
| 2nd Nitrate of Alumina, | 15°Bé=23°Tw. |
| 3rd Hyposulphite of Lime, | 9°Bé=13°Tw. |

PURPLE.

| | |
|---|---|
| Alizarine paste, 10 per cent. | 3 lbs. |
| Purple thickening | 10 quarts. |
| Pyrolignite of Iron, 12°Bé=18°Tw. | 6 ounces. |
| Acetate of Lime, 16°Bé=25°Tw. | 12 ounces. |

The printed goods are steamed for an hour or two and then hung up to air for 24 to 36 hours ; they are then passed in a padding machine through the chalk and arseniate of soda bath, as for reds, after which they are washed and soaped in a single soap bath without any crystals of tin, and if required cleaned with a little bleaching powder.

THICKENING FOR REDS.

| | |
|---|---|
| Wheat starch | 12 lbs. |
| Water | 40 quarts. |
| Acetic acid, 6°Bé=9°Tw. | 4 quarts. |
| Gum Tragacanth | 1¼ lbs. |
| Olive oil | 3 lbs. |

Boil the whole well together, and stir till cold.

THICKENING FOR PURPLE.

| | |
|---|---|
| Starch | 10 lbs. |
| Water | 27 quarts. |
| Acetic acid | 3 quarts. |
| Gum Tragacanth | 1½ lbs. |
| Olive oil | 2 lbs. |

Boil the whole well together, and stir till cold.

The mordants used for the above recipes, are prepared in the following manner, viz. :—

ACETATE OF ALUMINA.

30 lbs. hydrate of alumina are stirred into 6 quarts acetic acid, warmed, filtered and the solution diluted to the required degree.

The hydrate of alumina is prepared by dissolving

72 lbs. alum in 100 gallons of water,
62 lbs. soda in 100 gallons of water,

and mixing the two solutions ; the precipitate thus obtained is well washed, thrown on a filter and squeezed out and dissolved in the acid before it gets dry.

NITRATE OF ALUMINA.

| | |
|---|---|
| Nitrate of lead | 2 lbs. |
| Alum | 2 lbs. |
| Water | 2 quarts. |

Dissolve and separate the liquid from the precipitate by filtration, and dilute to proper degree.

The red is more yellow with nitrate, than with acetate of alumina, and when the first is used more acetate of lime must be taken in addition.

ACETATE OF LIME.

A solution of acetate of lime at 16° Bé contains 25 per cent. of acetate of lime ; generally one-tenth of the weight of alizarine paste is required, but it is safer, with a fresh quantity of alizarine, to ascertain on a small scale the quantity required. "*Alizarin.*" *By F. Versmann, Ph. D. New York.*

**Sizing of Cotton Goods.**—DENNS and HENTSCHEL patent the use of caseine dissolved in ammonia water for sizing goods previous to their being printed. They also employ such caseine solution mixed with glycerin as carrier for the print-colours. Addition of alum or potash bichromate to this solution renders the fabric waterproof.

[*Note by Abstractor.*—The use of caseine as a thickening material in cotton printing is not new. A very little cold water is added to the caseine, and about two to three per cent. of magnesia, giving a thick and gummy solution, which runs when exposed to heat, but not in the cold, the melted mass being soluble in alkaline liquids. When insoluble colours are printed with this solution they become fixed, in consequence of the running produced by steaming. The colours, however, will not wash. If the caseine is treated with a larger quantity of magnesia, say from five to ten per cent., a thick, semi-fluid, homogeneous paste is produced, which can be stirred around in water without giving a true solution. In baryta water this paste becomes a thin, gummy solution, well adapted for thickening. The solution can be kept for a long time without decomposition, but must be protected against the carbonic acid of the atmosphere. R. G.]

## § 4. *Food and Sanitary Matters.*

**Preservation of Meat.**—A new method is proposed which it is expected will solve the problem of how to keep meat fresh and pure for any length of time, and in any weather. The discoverer of the new mode at present remains incognito, as the proceedings necessary to patent the invention are not yet complete, and also retains the secret of the elements used in the process. Experiments have been made of the simplest possible character, and it only remains now to prove the efficacy of the means used to preserve the meat, by examining the joints subjected to the process, after the lapse of two or three weeks. Meat consisting of joints of veal, mutton, beef, &c., was placed fresh and uncooked in a separate tin case. These cases were soldered down, and a few drops of fluid poured in through a circular orifice at the top, which was hermetically closed immediately afterwards. The elements of the fluid will not be made known just yet, but it is understood that they consist of the gases which are essential to life in a living body, and which will, if properly applied, prevent decomposition and decay in a dead one (?). The patentee claims that his process will be equally

effective upon vegetables and fruit, and also upon human bodies after death. The small holes at the top having been soldered down the cases were sealed with tape and sealing-wax, and several gentlemen wrote their names outside. These are to be preserved for the space of three weeks, when another meeting will be held, at which the cases will be opened and the contents examined to ascertain the results of the experiment. *Daily News, April 30th.*

**Growth of Barley.**—LAWES and GILBERT have obtained the following results by growing barley for twenty years consecutively on the same land without manure and with various kinds of manure.

1. Without manure the average annual produce of barley over twenty years was about twenty-one bushels of dressed corn and twelve cwts. of straw; the quality, indicated by the weight per bushel of grain, was higher over the second than over the first ten years; but the quantity, of both corn and straw, was between 23 and 24 per cent. less over the second ten years.

2. Compared with wheat grown for many years in succession without manure, barley gave an average of more corn, less straw, and nearly the same weight of gross produce (corn and straw together); but the barley fell off more in produce of grain, and about equally in straw, over the later years.

3. Farmyard manure applied every year for twenty years, gave an average annual produce of more than forty-eight bushels of barley-grain, and twenty-eight cwts. of straw. The weight per bushel, quantity of grain and quantity of straw, were all considerably higher over the second than over the first ten years. The manure probably supplied from three to four times as much nitrogen as any of the artificial manures, and much more of carbonaceous organic matter, and of every other constituent of the crop, than was contained in the produce. It would leave a large residue of nitrogenous, carbonaceous, and other matters in the soil, which seem to be very slowly available for future crops; but the large accumulation of organic matter increases the porosity of the soil, and its capacity for the retention of moisture; and the crops are thereby rendered both less susceptible to injury from excess of rain, and more independent of drought.

4. As without manure, so with farmyard manure, barley, compared with wheat, yielded, over a series of years, more corn, less straw, but nearly the same quantity of total produce (corn and straw together). This is remarkable, when it is considered that the wheat is autumn-sown and autumn-manured, and the barley spring-sown and spring-manured.

5. Mineral manures alone gave very poor crops, and the quantity of both corn and straw fell off considerably during the later years; but superphosphate of lime alone gave more than salts of potash, soda and magnesia, and not much less than the mixture of all. It may be concluded that the soil was not relatively deficient in any of the mineral constituents which the manures supplied; and, from the falling off in the produce both without manure and with purely mineral manures, it is probable that the growth of the crop under such conditions is gradually exhausting the available nitrogen accumulated within the soil from previous cultivation, manuring, and cropping.

6. Over the same period of twenty years, a mixed mineral manure, containing salts of potash, soda and magnesia, and superphosphate of lime, gave, of barley, much more grain, rather less straw, but considerably more total produce, than of wheat. It is probable that, with the autumn-manuring for the wheat, the various constituents are distributed by the rains, or enter into less soluble combinations, or both, during the winter; that hence there is less active root-development in the upper and more highly nitrogenous layers of the soil in the spring, and that hence the barley is more rapidly exhausting the accumulated nitrogen of the surface-soil than the wheat.

7. By nitrogenous manures alone (ammonia-salts or nitrate of soda) much more barley was obtained than by mineral manures alone; the produce declined much less in the later years; and, for twenty years in succession, even fair, though not large, crops were obtained. This result is a striking illustration of the mineral resources of such a soil; and it shows that when in what may, in an agricultural sense, be called a corn-exhausted condition, it was deficient in available nitrogen relatively to available mineral constituents.

8. By ammonia-salts and superphosphate of lime together, an average produce of more than forty-seven bushels of dressed corn, and more than twenty-eight and a half cwts. of straw, or considerably more than the average barley crop of the country, was obtained over twenty years in succession; and the produce of corn increased, and that of straw in a less degree diminished, giving a higher total produce, during the later than the earlier years. Notwithstanding the great demand made upon the supplies of potash within the soil, by the growth of the crop for so many years by ammonia-salts and superphosphate without potash, the addition of salts of potash, soda and magnesia, gave no further increase of corn, and very little of straw and total produce. The potash-yielding capabilities of such a soil, and the beneficial effects of the use of superphosphate, with nitrogenous manures, for spring-sown corn crops, are here strikingly illustrated.

9. When the same mixed mineral manure, and 200 lbs. of ammonia-salts, were applied per acre per annum for twenty years, in the autumn for wheat, and in the spring for barley, the barley gave more than one-half more corn, nearly one-sixth more straw, and nearly one-third more total produce, than the wheat. When the same mineral manure was used with a larger quantity of ammonia-salts, the result was still in favour of the barley, but in a less degree than with the smaller amount.

10. After applying 400 lbs. of ammonia-salts per acre per annum to barley for six years, and then reducing the amount to 200 lbs., the plots so treated gave, for ten years in succession, more produce than those which had only received 200 lbs. annually from the commencement. It thus appears that the excessive supply of 400 lbs. had left a residue of nitrogen within the soil which was available for succeeding crops.

11. The experiments on barley with nitrate of soda and ammonia-salts respectively, are not exactly comparable with one another; but, so far as can be judged, a given amount of nitrogen, as nitrate of soda, has yielded more produce than the same amount of ammonia-salts, especially in dry seasons.

12. By the annual application of rapecake an increase in the crop of barley is occasioned, but in proportion to the nitrogen contained, less than by ammonia salts or nitrate of soda.

13. Over 20 years and more in succession ammonia salts or nitrate of soda with mineral manure (without silica), have yielded considerably more of both wheat and barley than the average crops of the country, and more also than either farm-yard manure or rapecake. It is obvious, therefore, that the return to the soil of carbonaceous organic matter as manure is not essential, so far as the successful growth of either of these crops is concerned. *Journal of the Royal Agricultural Society.*

**Arsenic in the Air of Rooms.**—The statement that the air of rooms, painted with green colours prepared with arsenic, contains the latter in quantities sufficient to induce serious, or even fatal effects in persons inhabiting those rooms, has been doubted, on the ground that the oxygen compounds of arsenic are not volatile at the ordinary temperature. FLACK finds that the green colour known as Schweinfurt green yields in a moist atmosphere *arseniuretted* hydrogen. The organic substance, starch, &c. used for fixing the colour favours the formation of that highly volatile poison. *Dingler's Polyt. Journ. ccvii.* 146.

**Arsenic in Potable Waters, &c.**—Dr. FRANKLAND stated that with regard to the diffusion of arsenic it was a matter no doubt which was going on to a much greater extent than was commonly imagined. He did not think himself that it had much sanitary consequence. It was a matter of his own knowledge that large communities were at the present moment drinking water which contained a marked quantity of arsenic without apparent effect. He would not mention the names of the communities, for no doubt they would begin to feel the effect directly they knew it. There was one case that had been brought forward by Professor Church many years ago of a little village on the west coast of Cumberland, where a fraction of a grain of arsenic per gallon had been found in the water, yet the people there lived to a good old age, and they did not complain of any evil effects arising from it; and he was informed that pilgrims came on purpose to drink of this water, which was used in all the domestic appliances in the district. Yet fish would not live in the stream, and ducks could not be kept upon it; but men and ducks differed very much in their habits, as also did fish. Ducks have the habit of picking up fragments of stone or rock present in the bed of a rivulet, and using them, he supposed, for grinding their food. This water came from an old cobalt mine and these pieces of rock had some arsenical traces, which proved fatal to the ducks. The fish probably did the same thing, and thus got traces of arsenic from the rock in the bed of the stream, for he had proved that fish could live for months in a box in this stream, if they were preserved from contact with the bed of the stream. That looked very much as if it were the rocks in the bed of the stream and not the water itself that was fatal to them. Whilst, however, the diffusion of arsenic in this way through the products which we consume in domestic use, through drinking water, through the atmosphere of our towns (for the smoke of London invariably contains arsenic), whilst he did not think that this diffusion of arsenic at all affected the health of the community, no doubt it might interpose obstacles in the way of the detection

of poison, and it was desirable if possible that it should be avoided.

Dr. C. R. A. WRIGHT stated that a number of experiments had been recently made on various products, and such things as soap, bicarbonate of soda, and other things of household use, and arsenic had been very frequently found to an appreciable amount. It had been shown to occur in common sulphuric acid in such great quantities that the mass of crystals of sulphate of ammonia obtainable by acting upon gas liquor with it, instead of being white and saleable, were perfectly yellow from sulphide of arsenic, and actually rendered unsaleable. Various manures were made by its agency, such as superphosphates, and in that way possibly it might get into food, for the arsenic would get into the superphosphate, and that being thrown on the land it would be taken up by the soil, and so find its way into corn and get into articles of food. Various drugs were actually found to contain traces of arsenic. Even although not often present in water or food, yet in articles of clothing it was frequently found in such quantities as to cause serious injury to health, and even death had been caused by the use of silk dresses dyed with aniline dyes. And as regards wall papers coloured green, that was a matter so well known and so clearly proved, that it was unnecessary to enter further upon it. *Journal of the Society of Arts, May 1st, 1874.*

## § 5.—*Fuel, Gas, Illumination, Photography, &c.*

**Valuation of Anthracene for Commercial Purposes.**—F. VERSMANN describes the following processes :—

### ALCOHOL TEST.

Take 20 grammes of the well-mixed sample, heat it in a beaker glass with 150 of alcohol, sp. gr. 825, till it boils gently; then cool it to 15° C. (59° Fahr.), bring it on a filter, and wash with so much alcohol that the filtrate measures 400 per cent. Dry the filter and residue in a water bath, detach the residue from the filter and weigh ; the weight multiplied by 5 gives the percentage. Mix the weighed residue well in a mortar, and introduce a small quantity into a narrow glass tube, about 4 in. long and one-sixteenth internal diameter, and drawn to a point at one end ; fix the tube and a delicate thermometer into a small paraffine or ozokerite bath, which heat gently and gradually. Note the moment the anthracene becomes liquid, *i.e.* when the first drop collects at the end of the tube, this is the melting point. Now increase the temperature to about 220° C., remove the flame, and note the moment the liquid becomes solid again, this is the solidifying point, which with good samples should be nearly the same as the melting point ; the mean of the two is the final point.

### BISULPHIDE OF CARBON TEST.

Take 10 grammes of the well-mixed sample, place it in a wide mouth stoppered bottle, together with 30 c.c. of bisulphide of carbon, shake up well and allow to stand for one hour at a temperature of 15° C. (59° F.) ; then bring the mixture on a filter, wash with 30 c.c. more bisulphide of carbon, and gently press the filter so as to dry it as much as possible ; then dry completely in a water-bath, detach the residue from filter and weigh ; the weight multiplied by 10 gives the percentage. The melting and solidifying points are taken as above.

### ANTHRAQUINONE TEST.

Heat in a flask 1 gramme of anthracene, together with 45 c. c. of glacial acetic acid till it boils gently ; add gradually, and at intervals of five to ten minutes, a solution of 10 grammes of chromic acid in 5 c.c. of glacial acetic acid and 5 c.c. of water. To prevent any loss of acetic acid during boiling, the flask is mounted with a condenser, which allows the acid constantly to flow back. About two hours' gentle boiling in most cases completes the decomposition, after which allow to cool, add 150 c.c. of water, and let stand for a couple of hours. Light yellow needles of anthraquinone separate from the green liquid. Bring the whole on a filter, wash the crystalline residue first with water, then with a very dilute, hot solution of potash, until the liquid runs off perfectly colourless ; and, lastly, again with water, to remove traces of alkali. Now dry the filter in a water bath, and when perfectly dry detach the anthraquinone with a spatula, and weigh. This last direction is given in preference to weighing the residue and filter, because it has been found that the dilute chromic and acetic acid dissolve part of the filter, the original weight of which would thereby be altered.

Before calculating the anthracene from the anthraquinone obtained, a correction must be made ; it has been found that 50 c. c. of acetic acid and 150 c.c. of water, as used above, dissolve 0.010 grammes of anthraquinone, which must be added to the weight actually found.

The following figures give an idea of the quality of the anthracene manufactured in Great Britain, as examined by F. A. MANNING.

ALCOHOL TEST OF 400 COMMERCIAL SAMPLES.

| MELTING POINTS. | Below 10 per cent. | 10 to 20 per cent. | 20 to 30 per cent. | 30 to 40 per cent. | 40 to 50 per cent. | 50 to 60 per cent. | 60 to 70 per cent. | 70 to 80 per cent. | 80 to 90 per cent. |
|---|---|---|---|---|---|---|---|---|---|
| Deg. Cent. | | | | | | | | | |
| Below 160 | ... | 1 | ... | 1 | ... | 1 | ... | ... | ... |
| 160—170 | ... | ... | 1 | ... | 1 | 1 | ... | ... | ... |
| 170—180 | ... | 2 | 4 | 3 | 3 | ... | ... | ... | ... |
| 180—185 | ... | 1 | 11 | 16 | 3 | 2 | 1 | ... | ... |
| 185—190 | ... | 7 | 21 | 30 | 20 | 18 | 5 | ... | ... |
| 190—195 | ... | 24 | 35 | 48 | 51 | 21 | 13 | 2 | ... |
| 195—200 | 2 | 9 | 6 | 10 | 5 | 6 | 5 | 2 | 1 |
| Above 200 | ... | 1 | 1 | 1 | ... | 1 | 1 | 2 | ... |
| Total | 2 | 45 | 79 | 109 | 83 | 50 | 25 | 6 | 1 |

BISULPHIDE OF CARBON TEST OF 250 COMMERCIAL SAMPLES.

| MELTING POINTS. | Below 10 per cent. | 10 to 20 per cent. | 20 to 30 per cent. | 30 to 40 per cent. | 40 to 50 per cent. | 50 to 60 per cent. | 60 to 70 per cent. | 70 to 80 per cent. |
|---|---|---|---|---|---|---|---|---|
| Deg. Cent. | | | | | | | | |
| 195—200 | ... | 2 | 1 | ... | ... | 2 | ... | ... |
| 200—205 | 4 | 13 | 16 | 12 | 9 | 4 | ... | ... |
| 205—210 | 5 | 24 | 47 | 35 | 6 | ... | 4 | ... |
| 210—215 | 2 | 11 | 32 | 8 | 4 | ... | ... | ... |
| 215—218 | 5 | ... | ... | ... | 2 | ... | ... | 2 |
| Total | 16 | 50 | 96 | 55 | 21 | 6 | 4 | 2 |

Bisulphide of carbon is much more active as a solvent than alcohol, and on treating one and the same sample with both agents alcohol invariably yields a higher percentage of insoluble with a lower melting point, while bisulphide gives a lower percentage with a higher melting point. There is no fixed relation between the two results. The product of the bisulphide test seldom has a melting point below 200° C., while with alcohol very few samples indeed show so high a melting point. The result of the bisulphide test is therefore much purer, and ought to fetch a higher price ; but as no definite rule can be adopted, the constant mixing up of the two tests is a great source of confusion.

The author gives the following table, based on his own experiments, as to the relation between the values obtained by the alcohol and bisulphide tests.

*Comparative Results of Alcohol and Bisulphide of Carbon Tests.*

| ALCOHOL. | | BISULPHIDE OF CARBON. | |
|---|---|---|---|
| Per cent. | Melting point. Degs. C. | Per cent. | Melting point. Degs. C. |
| 20 | 154 | 5 | 212 |
| 20 | 184 | 5 | 204 |
| 22 | 165 | 5 | 218 |
| 25 | 177 | 13 | 209 |
| 27 | 187 | 18 | 207 |
| 27 | 183 | 15 | 208 |
| 28 | 181 | 13 | 209 |
| 30 | 184 | 10 | 208 |
| 32 | 184 | 21 | 205 |
| 35 | 183 | 21 | 209 |
| 36 | 181 | 18 | 202 |
| 38 | 180 | 22 | 203 |
| 41 | 184 | 27 | 208 |
| 42 | 188 | 28 | 211 |
| 43 | 191 | 31 | 204 |
| 44 | 189 | 32 | 207 |
| 46 | 192 | 31 | 209 |
| 47 | 188 | 32 | 207 |
| 50 | 192 | 36 | 207 |
| 51 | 198 | 42 | 212 |
| 53 | 194 | 36 | 209 |
| 54 | 157 | 10 | 204 |
| 56 | 185 | 40 | 201 |
| 57 | 189 | 43 | 205 |
| 58 | 183 | 41 | 201 |
| 59 | 190 | 42 | 203 |
| 61 | 198 | 50 | 211 |
| 64 | 200 | 61 | 208 |
| 69 | 201 | 64 | 208 |
| 72·5 | 211 | 74 | 213 |

These thirty experiments represent samples varying with the alcohol test from 20 to over 30 per cent., with a melting point running from 154° to 211° C., while the bisulphide of carbon test varies from 5 to over 70 per cent., with a melting point of from 201° to 218° C.

The relative proportion between the two tests fluctuates with bewildering variety. With the low percentage the difference is as much as 4 to 1, with a vast difference in the melting point; but the higher the percentage the more uniform it becomes; with the last sample the alcohol is actually lower than the bisulphide with nearly the same melting point, namely 72·50 per cent. 211° C., against 74 per cent., 213° C.

Looking at the melting point only in all these tables, the bisulphide of carbon series are the most reliable as approaching the quality of pure anthracene; the last table of alcohol test gives only one-third melting above 190° C., whilst the previous table gives about two-thirds, the rest being only indifferent.

In order to compare the two tests, only those alcohol samples must be taken which melt at or above 190° C. The average proportion is then found to be about 3 to 2, but as the one product is much finer than the other, it must be clearly understood that it is so much more valuable, and no attempt should be made to simply substitute the one test for the other. Under all circumstances, it is desirable to improve the quality generally and to increase the percentage by separating the oil as much as possible. As long as this is not done, the samples to be tested should be washed with light petroleum spirit, and pressed and dried before using either alcohol or bisulphide; thus a more correct result is obtained, and more uniformity in the analysis insured. But, after all, these tests only give approximate results.

The anthraquinone test, although capable of giving perfectly accurate results when *pure* anthracene is operated on, is yet open to the objection that when a mixture of bodies is treated the conditions are changed, and no accurate correction can then be made for the amount of anthraquinone dissolved in the acetic acid mother liquor. Another drawback is the necessity of detaching the anthraquinone from the filter, which is simply impossible without scraping off some paper and losing some crystals.

But a still more serious objection is the fact that some of the other hydro-carbons are acted upon in precisely the same manner as anthracene, and their products are as little soluble in dilute alkali as anthraquinone itself.

Phenanthren dissolved in acetic acid is very slowly oxidized by chromic acid, so that after six or eight hours' boiling much is left unaltered; the phenanthraquinone forms needles of an orange colour, which melt at 205° C., and may thereby be distinguished from anthraquinone which melts at 273° C.; phenanthraquinone is further decomposed by heat into biphenic acid $C_{14}H_{10}O_4$; but this is a later reaction.

Chrysene, treated in a similar manner, yields also aquinone in orange-yellow needles, insoluble in alkali.

Thus two at least of the impurities, and perhaps the two most important ones, form similar compounds to the one which should stand alone in the whole series; the attempted separation is not complete, and the test is highly unsatisfactory. On the one hand the results are too low, and on the other hand they may be too high. *Paper read before the Society of Arts.*

**Constituents of Coal Gas.**—R. GASCH finds that the tarry liquors collected in the bent tubes immediately in connection with the gas-revolving retorts contain amongst other substances much bisulphide of carbon. The composition of coal gas differs considerably according to the season, and the distance the gas travels from the works. *Chem. Centralbl.* 1873, 56.

**Occurrence of Asphalt in America.**—In America asphalt occurs in large beds in New Brunswick and West Virginia—the material from the first place known as *Albertite*, that from the second as *Grahamite*. Both occur in fissures opened across their bedding in strata of the carboniferous age. There is little room for doubt that the fissures which contain the asphalt have afforded convenient reservoirs into which petroleum has flowed, and from which all the lighter parts have been removed by evaporation. Similar deposits, but of less magnitude, are known in the Colorado, Arkansas, Ohio and Kentucky. In Southern California, Western Canada, and elsewhere, asphalt may still be seen passing through the process of formation from petroleum, and especially in Santa Barbara and San Luis Obispo, where the accumulations of asphalt are well known to geologists. It also occurs on the shores of the Gulf of Mexico; but it is chiefly Trinidad to which the United States have to look for the greater part of the supply of asphalt for various purposes, especially for road-making. The quantity seems inexhaustible, and the quality is the very best, and its accessibility from the Atlantic cities of the States renders it much cheaper than any of the asphalts from the interior. *American Chemist*, 1872, 428.

## § 6.—*Miscellaneous.*

**Attractive and Repulsive Action of Radiant Heat.** W. CROOKES finds that when a bar of pith is suspended by a cocoon fibre, in a glass bulb from which the air is subsequently removed by means of the mercury pump, strong *repulsion* is shown when radiant light or heat is allowed to fall on one end of the bar. The heat of the hand is quite sufficient to produce this result.

A trace of air in the apparatus greatly diminishes the repulsive action. With sufficient air to depress the barometric gauge 12 millimeters, there is no motion, whilst with more air the movement is one of *attraction*. The action is in relation to the surface acted on, rather than of the mass.

When a bar of pith is suspended by a cocoon fibre, in a glass bulb from which the air is exhausted until the barometric gauge shows a depression of 12 millimeters, below the barometer, neither attraction nor repulsion results when radiant light or heat falls on the pith.

When a bar of pith is suspended by a cocoon fibre, in a glass bulb containing air at the atmospheric pressure, and radiant light or heat falls on one end of the pith, the movement indicates *attraction*.

When a glass beam, with plates of platinum at each end, is suspended at the centre by means of a torsion thread of glass, and furnished with a reflecting mirror, a ray of light from a lamp a few feet off is reflected from the mirror on to a scale, thus rendering visible the movement of the glass beam produced when radiant light or heat falls on one of the terminal plates of platinum.

The following experiment also serves as a good illustration:

A mass of magnesium is suspended from a fine platinum wire in a tube, forming a seconds pendulum. At the lower part two copper wires pass through the glass, and are connected with a platinum spiral, the other ends of the wires being attached to a galvanic battery. The platinum spiral is ignited by touching a key which turns the current on and off. Thus the radiant light and heat have not to pass through glass, but fall direct on to the suspended magnesium.

When the apparatus is full of air the ignited spiral *attracts* the metallic mass, and the attraction still remains as the exhaustion proceeds. The attraction is strong when the barometric gauge shows a depression of only one-tenth of a millimeter. On continuing to work the pump the attraction gradually diminishes until, when the gauge has become appreciably level with the barometer no movement whatever is observed when the spiral is made hot. If the mercury pump is now allowed to work briskly for several hours the gauge does not appear to rise, but the ignited spiral begins to exert repulsion; ultimately the repulsive action of radiant heat or light becomes stronger than was its attractive action when air was present; the barometric position of the neutral point dividing attraction from repulsion varies with the density of the mass on which radiation falls and in a less degree on the intensity of the radiation; in the case of pith it lies at about 12 millimeters below a vacuum, whilst with metal it is within a tenth of a millimeter of a vacuum. *Paper read before the Royal Society.*

**Silkworm Rearing in England.**—The committee of the Society of Arts have had before them specimens of English silk, the silkworms having been reared, the cocoons spun, and the silk reeled in the Exhibition, 1873. The silk was shown as a proof of the possibility of rearing the silkworm and producing a marketable result in this country, and with a view of stimulating a similar production in the Colonies, many of which, it is known, possess all the elements of success.

The silk was produced from seed known as the regenerated races, bred in the open air. The seed was brought from Orbe to the International Exhibition, kept in a cool airy place, and the hatching retarded as much as possible. On the 20th May, the eggs in the orchid-house, at the west entrance of the Exhibition, hatched at a temperature of 70° Fahrenheit. They hatched well, and the worms were carefully gathered in tulle nets and placed in the magnanerie. The worms kept in perfect health, and there was no sign of sickness or disease during any of the changes, nor was there any loss of worms, which, considering the variable weather, showed how strong and healthy the breed must be. During the second age about 100 worms were put out on one of the small trees, surrounded by a manchon; but smuts of the London atmosphere and from the three engines near the magnanerie working the machinery in motion, soon destroyed them. More worms were put out at the third age, but they also soon died out. The worms began to spin about July the 18th, and finished about the 26th. They were all mounted strongly, and formed their cocoons quickly and well.

The cocoons were all well formed and of good size, some being very large. The cocoons were then reeled by the persons working the reeling machinery in the Exhibition, and they reported the cocoons to be very good, and that they reeled with little breakages.

This silk takes a high classification, as the following report shows :—

"The sample of silk you have submitted to us we find to class with the best Italian, and could be used for the same purpose as Italian silks.

"It is of good nerve, clean, and fairly reeled, and we have no hesitation in saying that, had great care been bestowed, so as to have made the thread of ten deniers only, it would then have ranked with the choicest silk in the world.

"We roughly estimate this to be of about twelve or fourteen deniers; and as regards consumption, there is practically no limit. We should experience no difficulty in disposing of any quantity at current market rates. Taking the average of the prices of the last six years the value of this silk should be about 42*s.* to 43*s.* per lb.

"If, as you lead us to suppose, this silk can be produced in the Colonies, either in this form or as dried cocoons, we do not hesitate to say that a ready market can be found at Lyons or Marseilles, provided the article be sent in sufficient quantity.

(Signed) "DUFOUR BROTHERS AND CO."

One hank of the silk was exhibited in the Vienna Exhibition, and has been retained for the Economic Museum just established in that city. Other portions are now exhibited in the Lace Department of the International Exhibition of the present year at South Kensington, and one hank may be seen at the House of the Society of Arts. *Journal of the Society of Arts*, May 1, 1874.

**Wood Pulp for Paper.**—HOUGHTON uses the following process: The wood is cut diagonally by a series of knives, so that the fibre easily separates by the splitting of the grain. These slices are again broken in smaller pieces, furnishing the raw material for the next manipulation. This consists in introducing them into a boiler calculated to endure great pressure, and heated by hot water circulating in pipes which traverse it in sections throughout its length, the heat being capable of most accurate regulation.

The pressure employed in the process of treating the fibre is 180 degrees, and the wood is introduced into the boiler in wire cages running upon a set of rails, the small pieces after boiling being quite soft and of a dingy colour. This is next treated by means of chlorine in a vat, and the bleaching finished by the use of permanganate of potash. The material is now a soft, pulpy, and highly fibrous substance, which is next subjected to the action of a hydro-extractor, a kind of wringer, which leaves it in the shape of a damp, fleecy mass.

The liquid with which the fibre has been treated is then pumped into a vat, and subjected to the action of carbonic acid gas, which solidifies to some extent the resinous particles. It is next placed in a copper boiler, and heated exactly to the boiling point. This produces a complete coagulation of the resin, which falls to the bottom in large flakes. No use has been, so far, found for this resin, but it is expected that before long it may become of commercial value. *Dingler's Polytech. Journal.*

[*Note by Abstractor.*—According to more recent methods the resinous matter is extracted by boiling the woody fibres with caustic soda lye. R. G.]

**Chinese Lacquer.**—The varnish, which gives so much lustre to wood-work of all kinds, is simply a resin of rather reddish colour, extracted, by incision, from a tree indigenous to some provinces of China and Japan.

The mode of preparing and employing the varnish obtained from this resin is as follows. The first operation consists in removing from the juice of the tree all the water, and for this purpose it is exposed to the sun for two or three hours, being stirred all the time with a wooden spatula. Without the evaporation thus caused, the varnish would not possess its beautiful transparency. Certain substances are added to produce the varieties of varnish known in Chinese industry; thus, to produce the fine ordinary varnish, pig's gall and Roman vitriol dissolved in a little water; to produce the fine black Japanese varnish, of which the Chinese remained long ignorant, powdered hartshorn, charcoal, or ivory black is mixed in certain proportions with tea oil, and added to the resinous liquid.

The design is sketched on the varnished wood with a brush and white lead; a very fine steel point is then passed over the outlines so as to trace out all the details. More often, however, the design is first sketched with pencil on paper, and finished with Indian ink. These latter designs are then carefully brushed over with orpiment dissolved in water, and are immediately applied to the varnished wood, the hand being passed over the paper, so that all the parts of the design are transferred to the wood. When the paper has been taken off, all the lines are retouched with orpiment or vermilion in gum water, which fixes the design firmly on the lacquer, and then with varnish mixed with a little camphor, which renders it more liquid; and this, when dry, is ready to receive the shell gold in powder, applied by means of a puff or dabber, over the whole of the design; the surface is then lightly wiped or rubbed, when every line of the original design becomes brilliant.

When it is desired to bring portions of the design into relief, such as the inequality of the trunks of trees, the nerves and veins of plants, &c., the camphor varnish is applied over the gold, and the gold again over that, often many times, until the desired relief is obtained. All the important lines of the design, the eyes, lips, &c., of figures, the folds of drapery, and all the ornamental portions of the work are touched up carefully with the brush.

The lacquered work of Japan excels that of China, partly because of the superior transparency of the Japanese varnish, which is as limpid as the purest water, while that of the Chinese has always a yellow tinge; and partly because of the climate, the production of the best varnish requiring a soft, fresh, humid, and calm atmosphere; that of China is rarely temperate, almost always hot or cold, and charged with dust and salts, while Japan, being surrounded by the sea, has just the sort of air to dry varnish without causing it to become wrinkled or discoloured.

White lacquer is made by mixing silver leaf, carefully divided, with the ordinary varnish; red lacquer by the mixture of mineral cinnabar or carthanum flowers; yellow lacquer with the addition of orpiment only; green is produced by a mixture of orpiment and indigo; and violet lacquer by the addition to the varnish of a certain mineral of that colour, reduced to an impalpable powder. The older the articles varnished with the above, the more brilliant and beautiful are the colours.

The perfection of Chinese and Japanese lacquer work does not depend solely on the excellence of the varnish, or the careful preparation of the various colours, for the application of the lacquer demands the most elaborate pains. In the first place, the surface of the wood to be lacquered is prepared with the greatest care; when necessary the joints are filled in with fine tow and then covered with thin strips of silk or paper. The surface is then dressed with an oil obtained from a certain tree which grows on the mountains and highlands of China; when the oil is perfectly dry, the varnish is applied. With two or three coats of the varnish, its transparency is so great that all the veins and marks of the wood are perfectly distinct; to disguise the wood entirely many more coats have to be laid on, and, finally, the surface is made as smooth and brilliant as glass.

It is on such a surface that the gold and silver ornamentation is effected, and the whole, when finished, is preserved by a light coating of the varnish.

Another kind of lacquer is produced by covering the surface of the wood with a composition made of paper, tow, lime, and some other materials. This is laid on in the form of paste, and produces a solid and uniform ground, with which the lacquer amalgamates.

The lacquer and varnish are laid on with flat brushes with excessively fine hairs, at first in all directions, but equally, afterwards lightly and in one direction, each coat being allowed to dry perfectly before another is laid on. No single coat exceeds the thickness of the thinnest paper, otherwise irregularities would be produced which could not afterwards be corrected.

The workshops in which lacquered work is produced are closed in the most careful manner, in order to prevent the possibility of dust, the men even taking off all their clothes except a pair of drawers. Contrary to all European practice, the lacquered work is dried in places which are rather damp than otherwise, and the workmen exhibit the greatest ingenuity in keeping the atmosphere therein in perfect condition. When a coat of varnish is sufficiently dry, the slightest irregularities are removed by burnishing with an instrument made of a hard composition of brick, extremely finely powdered, and mixed with a certain oil, pig's blood, lime water, and a peculiar kind of earth, common in China. The last coat of varnish is not, however, touched with the burnisher, which would dim its lustre. Upon the perfection of this last coat all the beauty of the work depends, and the greatest care is taken that no particle of dust shall reach it, and no foreign substance touch it but the hair of the finest sable. *Journal of the Society of Arts, from the Courrier du Saigon.*

GEMS OF INDUSTRIAL ART.—EMBROIDERED CURTAIN.

## RARE POTTERY AND PORCELAIN.[1]

By L. Ritter.

IT is no very easy thing to make intelligible to those who have no love for pottery, who take no delight in curious or beautiful pieces of china and earthenware, how it is that very many of their fellow-mortals—not altogether despicable persons—are possessed of an enthusiastic liking for these things.

The truth is, that the causes of the prevailing love for old china lie both deep and wide. To the antiquary, to the student of past history, there is this attraction in the ceramic art, that its productions more perfectly adapt themselves to the fashion of thought, to the fancies and ideas of each successive generation of men, than those of any other human industry.

Pottery owes nothing of its beauty or its serviceableness to its material, for that is but the dust beneath our feet, and everything to the hand that fashions it and to the mind that directs the hand; so is it that it comes to have so purely human an interest: it is a bit of man's work with no adventitious aid whatever. If the form is beautiful, or quaint, or ugly, or commonplace, it is that the plastic clay has followed and exactly reproduced the conception in the maker's mind; it is formless, without coherence, and all but colourless, it takes the form, and the consistency, and the colour that are ideal with the man who transforms the grey earth into a piece of pottery, and, when he has done this, his handiwork lasts for ever.

Coins rust with time, statues of marble and bronze crumble or are corroded, inscriptions are obliterated, stone walls fall to the earth, and the pyramids themselves are slowly disappearing; every monument that mankind have thought most lasting yields to time except the work of the potter. The most frail of man's productions is yet the most permanent. The glorious tints on the majolica ware are still as bright as when they were drawn from the kiln, while the pictures of Raphael and Leonardo, painted in the same generation, are already fading. We have perfect specimens of Greek pottery which cannot be of later date than a thousand years before the Christian era. Glazed mural tiles have been discovered among the ruins of Babylonian palaces, still bright enough to decorate a king's chamber; and in the catacombs of Egypt are found glazed figures of Ra, the Sun God, of Anubis, and of the sacred Scarabæus, as pure and brilliant in colour as the latest productions of Deck or Minton.

While this permanence and the peculiar plasticity of its material make the study of ancient pottery indispensable to the archæologist and interesting to every intelligent person, its potentiality for extreme beauty of form and colour recommends it to all who possess any degree whatever of æsthetic appreciation. In regard to form-beauty it is enough to mention the exquisite proportions of the classical vases, amphoræ and cylices, the rich and various shapes of early Italian wares, and the more learnedly elaborated forms of the pottery of the Renaissance period; and of colour it is enough to say, that the precious imperial red of ancient China vies with the ruby in brilliancy and depth, the blue of the turquoise is exactly repeated on the blue crackle ware of China, while the pink and dark blue of the *Rose du Barry* and the *Bleu de Roi* of Sèvres, the rare Chinese apple-green, the exquisite tints on the ancient wares of Persia and Japan, are hardly equalled in the various qualities of depth, intensity, brilliancy, and tenderness by any colours in nature or in art.

The production of each one of these hues is a past triumph of invention and of applied science, and in the history of pottery is bound up the strong human interest furnished by the lives of the men who have advanced the art—the Della Robbias, the Palissys, and the Wedgwoods—men of science, artists, inventors, and endowed with the rare patience, energy, and devotion of true genius.

Such being the attractions afforded by the study of the ceramic art, it is no wonder that it is popular, and that its popularity increases with the intelligence of the age.

If it were allowable to cite names, those of many foremost statesmen, at home and abroad, of many great lawyers, of many men eminent in letters, and of many of our first artists, might be given as lovers and students of ancient and mediæval pottery. Mr. Gladstone at least may be quoted among the list, since he has not scrupled in a public speech to avow himself a keen amateur of fictile ware; the right honourable gentleman, indeed, is well known to be an enthusiastic and discriminating collector of the wares of Wedgwood and Northern Italy.

Whether we have any leaning or not towards the ceramic art, whether we really care for it or do not, it is the fashion to know something about old pottery. It has got to be a mark of inculture to be wholly ignorant; and to have, at least, read up Marryat or Chaffers has almost become part of a liberal education.

The man who first brought the light of science to bear on the whole field and past history of pottery, who analyzed, tested, examined, and classified the wares of all times and countries, was the Frenchman, Alphonse Brongniart. He it was who first reduced the crude mass into scientific shape, established a nomenclature, and in short, did for pottery what Linnæus had already done for botany. Every subsequent student of the subject, English and foreign—and their name is legion—has followed in his footsteps. It is not because of any failure of the respect and admiration due to a really eminent man that I propose now to depart, for the first time, entirely from Brongniart's system of classification, but because that system is, in my opinion—and I speak as a practical potter—the least valuable result of his labours. It is, however, impossible with my limited space to give the reasons which lead me to consider M. Brongniart's system of classification to be arbitrary, artificial, very complex, and very misleading.

Let us clear the ground by asking and answering the question, What is pottery? Any vessel formed of clay and more or less submitted to the action of heat, or *fired*, is to all intents a piece of pottery. If a child fashions a lump of moist clay into a bowl and bakes it on the hob, the result is as truly a piece of pottery as the transparent tea-cup of the Oriental porcelain, or the Sèvres vase which costs a thousand pounds. The term, therefore, is a loose one, and there is clearly need of an exact definition.

Into two great classes can pottery at once be divided; that whose surface is covered with a glaze—a glassy coating—and that which has no such glaze. A common flower-pot is a type of unglazed, and a tea-cup or dinner-plate a type of glazed pottery.

The substance of a piece of pottery, the clay of which it is composed, we English potters term the *body*, and Frenchmen *la pâte;* and I will take this opportunity of observing that the French-English word *paste*, introduced into their books by some English writers, is equivalent to *body*, and being redundant it is an unnecessary and even a foolish word.

A cup or bowl composed of *body* only is porous,[1] will not hold water, and slightly adheres to the lips when we drink from it. The glazing remedies all this, and it might be supposed that the remedy would have been applied forthwith; but it was not so, and men lived through long ages of comparative civilization with their pots, bowls, and vases still unglazed. Up to the Augustan age of Rome, earthenware in common use was unglazed, and the Falernian wine which Horace sang of was preserved in jars whose interior was rubbed with wax and tar to make them hold a liquid.

When the ancients did discover a glaze it was a very poor one. The learned are still disputing whether the varnish to be found on the Greek and Roman vases of the later period is a glaze or not. A scientific Frenchman has endeavoured to detach it from the *body* and to analyze it, and finding that he could not do so, like a true philosopher, he has denied it to be a glaze at all. At any rate it is not the comparatively thick coating of vitreous matter which we moderns understand by the word.

The invention of a true glaze is the first great era in the history of pottery. Glazed tiles have, as we have said, been found in the ruins of Babylon, and were in existence perhaps a thousand years—according to some writers two thousand years—before our era; but so far as Europeans are concerned, the art of glazing did not reach us till many centuries later, and practically we must believe the Arab races of Spain to have been either the transmitters of the secret from the East to our Western civilization, or else to have re-invented the art for themselves in about the ninth century.

To glaze pottery is to cover it with a smooth, shiny surface, impervious to water—to give it, so to say, a skin. Not so easy a matter as it might appear, for if the *body* be not skilfully compounded, it will not hold this coating, but will blister the glazed surface and form lumps, as may often be seen with the commoner wares; and if the glaze likewise be not exactly suited chemically to the *body*, it will either not adhere or will shrink and crack.

[1] By arrangements with the editor of "The New Quarterly Magazine," we are able to present to our readers this admirable paper, which first appeared in the pages of that work.

[1] Unless that body be prepared with peculiar skill, and by a peculiar method, as will be presently shown.

Now, every one, we suppose, is aware that glass is made of silica and some alkali. If flinty sand and soda, or potash, be mixed together in certain proportions, and submitted to great heat, the result is a glass of some sort. The glass or glaze which covers pottery is likewise so compounded; and the oxides or rusts of certain metals, such as the peroxide of iron which is iron rust, and the oxides of tin and lead, when used to help in glass-making, add certain useful qualities to the glass—among others, colour, and a certain capacity of adhesion—so also are these metallic oxides used in pottery glazes with the same good results.

Knowing these facts, we may go on classifying; for we may speak of lead glazes and tin glazes, and siliceous or pure glass glazes: these latter being, of course, glazes in which the metals have no part.

The second great invention on the road of progress was the tin glaze, the glaze first made having been a lead-containing, or, as the learned call it, a *plumbiferous* glaze. It was not till then that it was discovered that, by adding oxide of tin to the ingredients of the glaze, a species of opaque enamel could be produced, of an exquisite milky white, on which colours of various sorts could be painted. This grand discovery was the beginning of the art period of European pottery, so far, at least, as colouring is concerned, and it is worth while to dwell for a moment on the circumstances of the discovery.

The tin glaze, like many other good things, comes from the East. Tin-containing, or, in technical language, *stanniferous*, glazes are found with Egyptian mummies; on the splendid productions of the Persian potter, whose date we can only guess at; and in tiles from the Moorish palaces of Southern Spain. It is, then, to be supposed that this secret, too, lay long dormant among Oriental races, and was revived and communicated to European nations, with so many other half-lost arts, by the Arabs and Moors who conquered Spain. Tiles with tin glazes are found in the Alhambra, with a date corresponding to 1300 A.D., and there is no doubt that Moorish potteries were established in this and the following centuries, in Spain, in Portugal, and in Sicily, and wherever else the Moors had made their settlements.

The Moorish potters made a very beautiful ware, known to collectors as Hispano-Moresque, and easily recognizable by the peculiar metallic lustre on its surface. This ware was largely exported from Spain to Italy, insomuch that the most and the finest pieces are to this day found in that country, and not in Spain; and in time the Italians began to set up potteries of their own, and to imitate the Moorish ware. They called their imitations Majolica, or Maiolica—the ancient Italian name of Majorca—either because the Moorish pottery was made there or thence brought, or because the Italians fancied that it was.[1]

At going off, the Italian potters could not compass either the lustre of the Moorish ware or the rich, enamel-like glaze of these foreign potters, and their first works were lead-glazed, and are known to collectors as *half Majolica*, "mezza Majolica;" but towards the end of the fifteenth century they began to imitate the lustred wares. At last they got hold of the great tin secret, and their pottery soon surpassed the Hispano-Moresque wares in beauty. In the Moors' own speciality of lustred wares they were excelled by the Italians, and at the town of Gubbio a mode of imparting a lustre of a red colour of surpassing beauty was invented—a secret that was never disseminated, and soon lost; and the rare ruby-lustred plates of Gubbio are now among the greatest treasures of the art-collector.

So it was that this great secret of tin-glazing made its way to the country where art was rapidly arriving at its zenith, and where artists were soon to produce by its aid the Majolica ware of Castel Durante and Urbino, the glory of the potter's art.

It was during the period of the Renaissance that occasional specimens of the admirable ware of the Persians found their way to Italy. The history of this ware is still uncertain; we only know, that from a period which we cannot fix with any degree of certainty, the Persians had arrived at great perfection in the potter's art, producing works of a fine shape, an excellent glaze on a highly vitrified *body*, and a scale of exquisite blues, greens and reds, which have never been approached—shape, glaze, colour-harmony and *body*, being alike characteristic and original; so much so, that we can point with certainty to the period in the history of Majolica when the influence of the Persian ware began to be felt among Italian potters.

[1] The commonly repeated story of the Pisans bringing back with them the wares of Majorca after their conquest of that island in 1115, and of the name having thus been diffused, is not now much believed in. The date is too early, and the legend is quite unsupported.

While this activity prevailed in Italian art potteries, and before it culminated in the above-mentioned triumphs, a very remarkable man lived, whose genius did more than that of any other individual for Italian pottery. Luca della Robbia was born in 1400. He was a sculptor first, and a potter afterwards. An artist of the highest power, he was inspired with all the marvellous æsthetic force, and subtlety, and fertility of his age and of his country. He was not satisfied, as other sculptors are, with form-beauty alone, but cast about to add to his moulded figures the further beauties of colouring and surface-texture. He no doubt well knew the wares of the Moors of Spain, and probably was acquainted with the secret of the tin glaze already used by the Italian potters. It is needless to assume, as most writers do, that he discovered tin glazes for himself; but he at any rate adopted the process, and he has left us bas-reliefs and even life-sized statues covered with a fine stanniferous polychrome glaze, which are among the wonders of Italian Renaissance art, and which to this day are, in their way, unsurpassed triumphs of skill.

Very far inferior as artistic productions, and in technical ability, are the works of another great potter, the famous Bernard Palissy.

Born more than a century later, and in a country where the surroundings were far less congenial to art than the Italy of Della Robbia, Palissy did most certainly, among circumstances of the greatest difficulty, discover for himself, and teach his countrymen, the art of stanniferous glazing, probably arriving at its knowledge by analysis of the glazes on the Italian ware; for Palissy was a skilful chemist, and to discover the presence of tin in a glaze is a matter of no difficulty whatever. The story of his life, his struggles, his discouragements, and his disappointments, is a sad enough one to any reader, but to those who are themselves potters the tale is doubly pitiful; for we know that he spent his great genius in solving with imperfect means a problem that had already, and long before, met with a perfect solution, and that the labour of a lifetime was wasted in learning what the poorest Italian potter could have told him in five minutes.

The Palissy ware has an attraction from the history of its maker. There is little technical merit or successful potter's skill, as the writers of his life always assume that there is, in Palissy's work: the glaze is poor, the colouring dull, though, as a rule, harmonious; the *body* is very coarse and earthy. The chief merit of the ware is in the originality, the artistic beauty and naïveté of the modelling of natural and other subjects encrusted on the surface.

While tin-glazed pottery was thus being made in Italy, and, a century later, in France, the Germans would seem not to have been idle; or rather, perhaps, it is that the patriotism of Germans of the present day has not been idle. It is stoutly maintained, and perhaps actually believed, that a stanniferous glaze was used by a potter of Schelestadt, in Alsace, somewhere about 1250. There are indeed to be found in Gothic German buildings of even an earlier period than this, fine specimens of glazed decorative pottery, with the artistic characteristics of the time and country, and minute portions of tin may perhaps be detected in the glazes of these wares; but its presence in the thirteenth century pottery of Germany is cleary accidental; it is not there in such quantity as to influence the appearance of the pottery, or to merit for it the title of stanniferous.

In the Low Countries, tin-glazed pottery was made in the middle of the fifteenth century, and these works developed at a later date into the famous Dutch potteries, whose productions are known as Delft, of which we shall have more to say anon.

Before we enter upon an account of the great turning-point in the history of European pottery, we must dwell for a moment upon the works of another great Renaissance potter.

It was so late as the year 1832, that M. André Pottier, a French writer on art, first announced to the world the existence of the singular species of pottery now known as "Henri Deux" ware. He gave it as his opinion that it was the production of Florentine artists working in France. Until thus brought to the knowledge of connoisseurs, the very existence of this exquisite ware had been forgotten. It soon, however, became famous. Every corner of Europe was ransacked for specimens of it. Dukes, princes, and millionnaires contended with the heads of national museums for the few pieces still to be found. No ware ever yet became so costly; for every hundred pounds that a rare piece of Sèvres or Majolica will fetch, the "Henri Deux" will bring its thousand. As yet only about fifty pieces have come to light; and of these fifty, more than one-half have found their way into the galleries of our wealthier English amateurs.

Those who see a specimen of this rare and precious pottery for the first time are apt to be extremely disappointed. They see a vase, or a ewer, or a candlestick of fantastic shape, covered

with a thin, greenish yellow glaze, the colouring not by any means brilliant, and the surface seemingly inlaid and encrusted with the innumerable details of a most elaborate ornamentation, made out in quiet browns, blacks, and sad neutral tints. Nothing is less striking to a casual or an ignorant observer—nothing in the whole range of decorative art so absolutely exquisite in design and effect to the cultivated appreciation of a connoisseur in Renaissance work.

No sooner was the ware discovered than speculations began as to its maker, its date, and the locality of its fabrication. On no single point did the ten or twelve French writers on the subject come to an agreement, and a certain amount of unsolved mystery still attaches to all these points. There is no so-called "potter's mark" on any of the pieces except one, and this solitary mark is not recognizable as that of any known potter. It may be tortured into a monogram, or assumed to be a device, at the pleasure of those who form their various theories on the origin of the ware.

The pieces are decorated with the arms of French royal and noble families. One piece has on it the salamander surrounded by flames, the device of Francis I. of France, and very many out of the fifty bear the well-known monogram of Henry II. worked into the ornamentation of the surface — a circumstance which has given the ware its name. The date is, therefore, more or less fixed to the short period between 1540 and 1560, or twenty years. As to the nationality of the artist, the best authorities join in thinking he must have been a Frenchman, because the work is essentially of the style of the somewhat distinctive French Renaissance then prevailing. The precise locality of its production could only be inferred to be somewhere in Touraine, because a majority of the pieces can be traced as coming from that province.

Such was the mystery which hung about all connected with this curious ware; a mystery which not a little enhanced the interest taken in it, and perhaps the estimation in which it was held.

This mystery is now, to a great extent, cleared up.

At the Court of King Francis lived a widow lady of high birth, named Hélène de Hangest. Her husband had been governor of the King, and Grand Master of France. She was herself an artist, and a collection of drawings by her of considerable artistic merit is preserved. They are portraits of the celebrities of the period. She was in favour at Court; the King himself composed a rhymed motto to each of her portraits, and some of these verses are written in his own hand. It is established that Hélène de Hangest set up a pottery at her Château of Oiron, and that Francis Charpentier, a potter, was in her employ. To his hand, under the auspices of the châtelaine of Oiron, is due the famous ware of "Henri Deux."[1]

Mr. J. C. Robinson gives it as his opinion that the technical merit of the "Henri Deux" ware is very small. With due deference to Mr. Robinson, who, as a rule, writes well and learnedly upon this and cognate matters, we do not think he would say this if he had been able to appreciate the subject from a potter's point of view. The *body* of the "Henri Deux" ware is of admirable texture and quality; the mode in which the various clays are incorporated into the substance of the pieces without shrinking or expansion, the clearness, thinness, and smoothness of the glaze,—which, by the way, is plumbiferous; —all these things are so many marvels of skilful manipulation, and fill the mind of a practical potter with admiration.

We have hitherto been speaking of those sorts of pottery of which the *body* is chiefly composed of natural clays, and, while telling the story of the progressive steps towards improvement made in the fabrication of these wares, we have been able to make some sort of classification as we went on. We have shown how at first all European pottery was unglazed, as in the case of the more ancient Greek and Roman vases; how in time it got a sort of glaze, which was, in truth, only a thin varnish of vitreous matter, a sort of apology for a glaze; how, after several centuries, lead-glazing was thought of, and finally tin-glazing; and how this latter is divided into lustred and unlustred ware, the lustre being nothing but a surface layer of pure metal, gold, silver, or copper, spread so thinly as to be absolutely transparent. We have shown how the glazes on all the great Renaissance wares (except the very peculiar "Henri Deux"), that, namely, of Luca della Robbia, of Palissy, and of Delft, are all tin-bearing; differing widely enough from each other in appearance, but each substantially compounded of similar ingredients, the body of each being always chiefly composed of clay, and lime, and silica, and the glaze always having tin for a principal ingredient.

[1] The evidence of all this seems complete. It is stated at length in the recently published monograph of M. Benjamin Fillon.

There is still another important fictile ware, known under the general term of Flanders stone-ware (*grès de Flandres*). It has these special characteristics: the *body* is still formed chiefly of natural clay, to which is added some proportion of flinty sand. Jugs and drinking-pots of this ware have a considerable thickness, and in consequence a somewhat clumsy appearance; but the most remarkable characteristic is the glaze, which is neither metallic nor siliceous in the sense in which those expressions have hitherto been used. The glaze differs, too, most completely in the mode in which it is put on, from that on every other kind of ware. In all other pottery whatsoever, the *body* is first fired, and when again cool is dipped, in its porous state (known as *biscuit*), into, and thickly covered with, a composition made by grinding the ingredients of the glaze to powder, and mixing them into a cream-like paste. The bowl, cup, or whatever it is, coated with this creamy stuff, is then returned to the furnace, and when again taken out, the surface is found to be covered with its glassy skin, or glaze. Not so with the ware known as *grès de Flandres*. It is fired, and then replaced in the glazing kiln in its *biscuit* condition. A quantity of salt is then thrown into the kiln, the fires lighted, and a very strong heat produced. The salt is thereby evaporated or converted into gaseous fumes, and these strike upon the clay and flint, or silex. Now we all know, or ought to remember, that salt is a chloride of sodium, or less scientifically, a *muriate of soda*, and this same soda flying up and encountering the silex of the *body* in an incandescent state, joins with it to make what the learned call a silicate of soda, and the ignorant, soda glass.

As may be supposed, the coating of glass which reaches its destination in this airy fashion is thin and slight; it is also transparent, and shows beneath it the grey natural colouring of the clay. No colours can stand the fierce heat necessary to evaporate the salt except cobalt blue, consequently the *grès de Flandres* has but this one colour, relieved by the rich browns, the greys, the black, and the whites of the various clays employed.

Simple as its scale of colours, the *grès* is yet susceptible of artistic treatment of a very high and very elaborate kind. Encrustations of clay moulded into bas-reliefs, armorial bearings and legends in Gothic character, diversify its surface. The strength and solidity of this pottery—it can be thrown to the ground without breaking—have caused it to find special favour among northern nations. It was made throughout Germany. At Nuremberg, that great Middle-Age art centre, the ware was exquisitely wrought; at Cologne and in Holland, in Flanders, and at Beauvais in Northern France, *grès* was also fabricated. Much of the ware was imported into England during the sixteenth century. The brown and grey jugs often sold by dealers as old English, and known as "grey-beards," are usually of this imported ware.

Such was the progress of the ceramic art, and such the various kinds of decorative pottery made in Europe during its most palmy period, the sixteenth and seventeenth centuries. Towards the end of the latter century the art productions of the potteries of this continent began to be competed with, and in time nearly swamped, by the productions of men who were far more accomplished potters than those of Europe, and whose manufactures —infinitely inferior in true art value to the Majolica, the stoneware of Flanders or Germany, or the various earlier wares made in France—yet recommended themselves highly by their delicacy, their transparence of *body*, and their brilliancy of colouring.

In China the potter's is a very ancient art. The date of the first fabrication of pottery is lost in the distant mists of early Chinese history; the native chronologists themselves are not too sceptical to assign it to about the year 2698 before the Christian era; the discovery of true porcelain, as fixed by them, having taken place under the Hau dynasty, between 185 B.C. and 88 A.D. Without drawing so largely as this upon his credulity, the reader must yet believe that wares corresponding in texture and appearance to our glazed stone-wares and *faiences* were made by them many long centuries before they were dreamed of in Europe.

The Chinese had early made one important discovery which they long kept to themselves, and which relieved them of a great many of the difficulties which in our ignorance of it were incidental to our making of glazes. They had found a material which combined in itself silex, an alkali, and alumina; in fact, a substance which contained in itself all that goes to make a glaze. This was the variety of felspar which mineralogists call orthoglaze—a hard grey stone, known to the Chinese as petuntze. This rock is occasionally found, as geologists term it, *degraded*, or decomposed; in other words, reduced by the action of the atmosphere to powder. The rain falls on it in this state, and makes it into clay, and in doing so washes from it all that water will melt; that is, deprives it of its alkali. In this state it is the

famous kaolin of the Chinese, the possession of which has enabled them to make the semi-transparent pottery which we call china or porcelain.

The kaolin is a pure white clay, absolutely infusible by heat; being mixed with the before-named *petuntze* ground to powder, the addition of potash thereby obtained renders it slightly fusible—slightly disposed, that is, to run into glass when fired. It stops short of this point, and yet it is far more vitreous than the common clay pottery we have hitherto been dealing with. It is precisely in that intermediate condition between glass and earthenware which we know as porcelain.

The appearance of this beautiful ware, vying in tender colouring with the petals of flowers, its painted surface elaborate as the wings of butterflies, its substance delicate as the thinnest shell, and with the translucency of pearls and opals, was the death-blow to the coarser wares of Europe. The first specimens of true porcelain were imported at the beginning of the sixteenth century, and fetched enormous prices; and the decadence of the various Renaissance wares dates from the time when the markets of Europe began to be flooded with oriental China ware.

We have in this paper been dealing almost exclusively with the history and practice of the potter's art in Europe, treating of the various wares of China, Persia, and Japan only incidentally, and so far as they have affected the progress of the art in this continent. We have shown how the Persian wares reached Italy during the Renaissance period, and stimulated the pottery painters of that country to some emulation of their fine colour harmonies; how the art of the Arab potters reached Italy through Spain, and how greatly it influenced the Italian *fabriques*.

We have now to show how the pottery processes of all Europe were changed by the influence of China.

There was a long period during which any emulation of the newly-introduced porcelains would seem to have been thought hopeless. The potters of Europe were indeed busy enough during this period, but they were without the only materials with which true porcelain can be made, the kaolin and the petuntze, and their activity for more than a hundred years—that is, from 1600 till towards the middle of the following century, when European porcelain was first made, was an activity that resulted in quantity rather than in quality of art work.

Every one who has studied the history of art generally during this century and a half knows that it is one of rapid decadence. All the great masters in painting, the Raphaels, Titians, Leonardos, and Michael Angelos, the Van Eyks and Albert Dürers, had passed away in the generations preceding. The men who succeeded them, great indeed, were by no means worthy to hold places in this illustrious roll, and after the first fifty years they were replaced by artists of still inferior merit.

The art of pottery sympathized with the decadence in the other arts. Technical processes improved, but the genius of the art was dead. The best work was done in France; it was a pale reflection of the fine art work of Italy, and it gradually got more and more impenetrated by the French spirit, which has not often been either rich or interesting except when it has derived inspiration from Germany, Italy, or Flanders, and is, at its best, seldom quite free from a clever meretriciousness and a finikin prettiness quite the opposite of true art.

Louis Gonzaga, Duke of Nevers, set up, with the help of some potters from the great Urbino workshops, a manufacture of Majolica at Nevers.[1] The Nevers ware soon lost its Italian character, and got in process of time to be more and more Gallicised. It was never original, always an imitative art work. After following the traditions of the Majolica potters, it attempted to reproduce the fine colour harmonies of the Persian ware, then to imitate the pseudo-orientalism of the Delft, and last of all it got to be almost entirely French.

At Rouen, also, a famous *faience* was made; and this, even at going off, was of quite unmitigated French taste—that is, of quite bad taste. In order that the reader may not think that we are unfairly biassed against French work and French art of this period, we will quote from M. Jaquemart's well-known and important work a sentence which shall, to all right-judging critics, condemn the Rouen earthenware, for which this author can find no praise too high. At first, says M. Jaquemart, the ornamentation on the Rouen pottery was not well defined; but very soon the imitation of the designs on Oriental porcelain suggested to the potters of Rouen the true style and type of work which was to make them famous and constitute the glory of French pottery, and this true type was ornamentation *in imitation of lace-work and scallop-shells*:—"Le vrai type qui devait faire leur gloire et celle de la faience française tout entière, c'est le décor à *lambrequins et dentelles*."

That a man should be so lost to all sense of right taste as to see anything like glory in such pitiful stuff as this, is of itself a measure of the acceptance of true art canons across the Channel. In Rouen pottery, however, much as it falls short of the better work of a previous age, there is more than what M. Jaquemart finds to praise. Trivial as the motives of the ornamentation are, there is a certain harmony and even vigour of line and colour, and an ingenuity of design, which still find their admirers.

The pottery of Moustiers, in the south of France, though its colouring is poorer than that of the Rouen ware, and far poorer than that of Nevers, is superior to both in design. The slender arabesque drawings, on a pale or sad-coloured ground, are characteristic of this earthenware of Moustiers. All these three French potteries are represented in the museums of Europe, as are likewise the productions of a host of less known manufactories, which often pass for the wares of Moustiers, Rouen, and Nevers. We do not care to dwell on the work which these potteries turned out. As it receded further from the Italian type of bold, sweeping curves of design, and got more angular and finikin, so much the more is it undeserving of notice. It will be interesting, however, to observe how, on its way to the goal of complete meretriciousness, the art of pottery in France was arrested, in a curious manner, by certain foreign influences.

Our survey of the history of European pottery, modest as are our conceptions of the scope of the subject, and of our power to deal with it, will oblige us, for an instant, to dwell on something approaching to *la haute politique* itself.

The French nation—in mere cleverness superior, perhaps, to every race that ever existed—is also more than any other nation imitative and receptive of foreign ideas in art, in politics, and even in religion.

During the long decadent period of which we have spoken (which, for want of a better name, we will call the post-Renaissance period), the whole of France was moulding itself—under the influences, successively, of an Italian regent-queen, of a half Italian king, and of a great minister born and bred in Italy—to notions that were essentially Italian. It might or might not be detrimental to the nation to be ruled with that mixture of finesse and despotism which was in vogue in Italy, or to have to accept an Italian Churchman's strict notions of Church government; but it was, beyond question, for the advantage of the country that Italian art-taste should be substituted for that which was native.

True it is that art in Italy itself, at this time, was not thoroughly good; moreover, French subserviency to foreign influences was, as usual, excessive, and was soon carried to a quite absurd extreme.

When Louis XIV.—himself little of a Frenchman by blood, and still less in tastes and education—came to the throne, he inherited the fruits of the training which his predecessors had bestowed upon his people. His despotism was more absolute than theirs, and he ruled the fashion in art as arbitrarily as in other matters. All France bowed down before the "Grand Monarque," and followed his taste implicitly—the very art-world itself seeming to see in the great full-bottomed *perruque* of their despot their highest ideal of form. We can really trace something resembling the curls of this magnificent wig in all the art of the day: in the twirls, and flourishes, and spirals in stone of the architecture of that great period; in the sculpture, with its swelling drapery blown to all the winds of heaven at once; in the redundancy of bold, curling outline of the Court painters; even in the twists and turns of the furniture; and, markedly enough, in the ornamentation of pottery. Here, as always, the spirit of the generation of men that made it is more present than elsewhere; and here we see the prevailing taste for the so-called *Rococo*[1] in all its glory, and here the curl of the great wig is especially conspicuous—a style of art too forcible, too broad, with too much wealth and flow of outline to be French; and with too much purposelessness, and too many sins against taste, to be entirely Italian.

When the *Rococo* style wore out, it was to make way for a pseudo-classic taste; and under Louis XVI. some sort of chastening of French art took place, and some fair second-rate work

[1] Such ware got in France to be called *Faience*, after Faienza, in Italy, one of the chief places of its manufacture; and the word *Faience*, meaning simply glazed pottery, neither stone-ware nor porcelain, has been disseminated throughout all European languages, and is so useful a term that, as the reader sees, we have not been able to do without it.

[1] *Rococo* is a term applied by the French themselves to the art of his successor's reign—not very advisedly, as it seems to us. The true *Rococo* was born under Louis XIV., and yielded to more classical inspiration under Louis XV. and his successor.

was done in all branches of art, and especially in pottery, before the time of that deplorable abyss of taste, founded on a servile classicism, which the French know as "*Style Empire.*"

We have thus dwelt at some length upon art-work in France during this post-Renaissance period because, while the French sovereign—king or emperor—has always ruled the taste of France, France has guided that of Europe. During this period Spain followed the *Rococo* taste at Talavera; the Dutch Delft-ware potters, abandoning their Oriental models and adopting the French style, often turned out vases and jars which the uninitiated may easily mistake for the later Rouen ware. The Germans, slow adopters of French ideas, accomplished little in the way of *faience*-making, but at Höchst some good *faience* was made—always, however, without departing very far from the models of their western neighbours.

In our own country, till the middle of the eighteenth century, there is little movement in the potter's art to note. In Staffordshire, some very rude stone-wares had been made from about the year 1580. At Fulham and Lambeth, nearly a century later, some Dutchman set up a manufactory of Delft, very inferior to the true Delft made in Holland. Again, William of Orange brought to England in his train the brothers Elers, Dutch potters; and they established works near the clay-beds of Bradwell, in Staffordshire. They were excellent potters; the *body* of their ware is usually reddish in colour, is close in texture, and the surface is decorated with raised flowers and foliage ornaments in sharp relief. The pieces are sometimes impressed at the bottom with the word "Elers," and this has been a temptation to fraud. The majority of Elers ware in our collections is probably fictitious.

The Elers tried to keep the secret of their trade, and to carry it on in peace; but the jealousy of their neighbours drove them from their works, and a rascal named Astbury managed to swindle them out of their trade-secret, and to set up on his own account. He afterwards discovered by accident for himself a mode of burning flints into an impalpable powder; to mix this with clay was a long step on the road of pottery-making.

The time was coming, however, when a new light was to arise who was to revolutionize the potter's art, and to take away from England the reproach of being far behind the other great nations of Europe.

Wedgwood was more truly a potter than any of the other great men we have mentioned in this paper. He was born in the Potteries, the son of a potter, he was apprenticed to a potter, and he worked at the potter's wheel himself. There are no less than three fairly good biographies of this remarkable man. We have the less need, therefore, to say much about him. Wedgwood was singularly fortunate in his life, as well as deserving of good fortune. He early secured the patronage of Queen Charlotte, and his *Queen's Ware* (she desired it might so be named)—a cream-coloured, glazed earthenware—quickly acquired a reputation and a sale. He had the luck and the wisdom to connect himself with a gentleman of wealth, artistic taste, education, and business habits—Mr. Bentley, of Liverpool—who became his partner, and encouraged him to follow his bent towards the higher forms of the potter's art. As great a stroke of fortune was his securing the services of Flaxman—a man who, if his genius had not been cramped by the narrow classicism of the day, would have probably left a name among the very greatest in art.

Wedgwood was not satisfied with the glazes then used in earthenware. He had, indeed, himself discovered some good ones, but the best did not satisfy his practical mind. All the glazes of the day were liable to crack with heat, and to become unserviceable. He determined to dispense with them altogether, and to supply the deficiency by a body so carefully prepared that it should be at once compact enough to hold liquids, and at the same time possess something of the smoothness of a glazed surface; in fact, his idea was to cause the glaze to permeate the whole mass, and not simply to lie on the surface as a skin. He succeeded, and every one knows the Wedgwood ware of tender grey blue, of the less valued dark blue, and of the so-called sage green, most esteemed of all; on these wares the even surface is relieved by raised ornaments—leaves or figures—in white. Wedgwood also made a pure black body of great beauty. Furthermore, by using baryta with his clay, and mixing certain metallic oxides with the mass, he made a curious, beautiful, and now greatly-prized imitation of jasper; it was so hard and compact, and so little brittle, that it would bear to be filed and rubbed into taking a polish.

Wedgwood was a truly admirable potter, and his merits appeal particularly to one of his own trade. His bodies were so perfectly compounded, his *firing* so skilfully conducted, that never is a flaw or a speck perceptible, no shrinkage or warping or unevenness is ever seen in a piece of his ware; but the eye at last gets tired of so much regularity and so much perfection. There is so much classical "elegance," such almost mechanical faultlessness of shape and drawing, such an adherence to the forms and types of the best periods of classic art, such unvarying and level excellence, that at last one almost wishes for an occasional deviation into individuality, even at the expense of correctness.

The one thing wanting in Wedgwood ware is this individuality: it is hardly art-work at all; it is not the artist's own handiwork like a Palissy dish or a Della Robbia *plaque*, only an exquisite art manufacture.

We are now approaching an important epoch in the history of pottery. We have shown how from the time when porcelain was introduced into this continent, the work of European potters had been disdained, and least neglected as it approached most in character to the admired wares of China. It had been the constant object of potters to imitate the delicately pencilled colouring and the beautiful translucency of the imported porcelain. The discovery of the secret of this translucency was the discovery of the means of certain wealth: it was the philosopher's stone of the potter, which he was for ever dreaming of, and which he knew would transmute his clay into gold. Strangely enough, alchemy and the search after the great hermetic mystery, which had indirectly done so much for European science, has done this for art, that it has laid bare the secret of porcelain making.

During the reign of that ambitious and able prince and successful china collector, Augustus II., Elector of Saxony,[1] a young scamp named Bottcher had fled for protection to his capital from Berlin, where he had been employed as a druggist's assistant. He had been suspected of pursuing researches in alchemy with, probably, some imputed recurrence to the black art. On reaching Dresden this story accompanied him, and the curious and superstitious sovereign caused him to be brought into his presence. Bottcher was questioned by the elector, but he denied any knowledge or any practice of alchemy. Augustus was not satisfied. He was himself employing one Schirnhaus, a professed adept, in experiments to discover the universal medicine; to this person Bottcher was handed over by the Elector, and in company with him and to please his royal patron—perhaps credulous himself—he busied himself with all the apparatus of the alchemist's laboratory.

One crucible full of earths and chemicals, when it was taken from the furnace, contained a semi-vitreous substance, which the shrewd Bottcher recognized as not unlike the material of which the Elector's highly-prized oriental porcelain was composed. He communicated his discovery to his patron, and was encouraged to persevere; but, lest he should escape with the news of it, Augustus shut him up in a royal castle near Meissen, supplying him with crucibles, retorts, chemicals, and furnaces, and providing him with every comfort and luxury except his liberty. In this semi-imprisonment Bottcher slowly worked out his discovery. In the presence of the Elector himself, he one day drew from the furnace a teapot of something not unlike porcelain, and threw it into cold water. The teapot was not injured, and thus one difficulty was surmounted. In the year 1709 he produced the very first piece of true china that ever had been made in Europe, with all the whiteness and translucency, but unfortunately without the strength and durability of the oriental ware, for it had bent and cracked in the fire. It was not till six years later that he made perfect porcelain, with its full beauty, and its full power of resisting heat.

The Elector had already established a manufactory, and made Bottcher its director. Here it was, at Meissen, near Dresden, that the first and also the best true china in Europe was produced. For a time it was a close secret. The workmen were sworn to silence on the processes they adopted: the walls were placarded with the warning words, "*Geheim bis ins Grab*," "Be secret till death;" but the dissemination of the secret could not long be prevented. A workman escaped with it to Vienna; another carried the secret to Höchst in Mayence; from Höchst it was carried to Fürstenburg in Brunswick, and to Frankenthal in Bavaria, and finally it reached Berlin. At all these places, and at several other German centres, true china was manufactured of more or less excellence, before the middle of the eighteenth century.

It may be laid down as a general proposition that to make true *hard* china, the kaolin and petuntze of the Chinese, or at least the kaolin, the so-called china clay, must be used. The present writer has not a vestige of a doubt that it was used by Bottcher in his first successful experiments, and that it was imported from China in its crude state; but a fortunate chance enabled Bottcher

[1] The famous "Green Vaults" of Dresden, containing the finest collection of oriental china in the world, were built and filled by the Elector Augustus.

to procure the precious clay in Saxony itself. An ironmaster of the Erzgebirge, one Schnorr, passing on horseback through the hilly country near the Aue, found that his horse's feet sank deep and nearly stuck fast in a sort of morass, and looking on the ground, saw that it was composed of a white clay. He knew nothing of porcelain making, but he thought at once that, being dried, this brilliant white earth would make a good substitute for hair-powder, then fashionable. He did accordingly bring it into the market as hair-powder, and much of it was sold for that purpose, under the name of "Schnorr's white earth." Bottcher used it, and was struck by its weight, and probably by its resemblance to the china clay. He examined it, and found that it was a true and fine variety of kaolin. This curious discovery was the source of the commercial success of the Dresden china manufactures.

It is time to say something about the classification of porcelain into *hard* and *soft*, a difference much insisted upon by collectors. The truth is that the so-called *soft porcelain* is not porcelain at all. On the way to the discovery of true china ware, which is hard, compact, and not to be injured by heat, which is serviceable as well as beautiful, which comes out of the furnace in the shape in which it goes in, neither shrunk nor warped—on the way to finding out how to make this substance, the potters of Holland, so early perhaps as a hundred years before Bottcher's discovery, and those of St. Cloud in 1695, had learned to make what is known as *porcelaine à pâte tendre*, china with a soft *body*. This ware possesses nothing but the appearance of true porcelain; the *body* is white and semi-transparent indeed, and the glaze is usually of a soft-looking, creamy white, but the ware is brittle, light, and generally unserviceable; the surface is so soft that it can be scratched with a steel point. It is fired at a very low temperature,[1] and yet four out of five pieces are, or rather used to be, destroyed by the heat of the kiln, consequently it is rare and expensive.

The making of this soft porcelain at St. Cloud encouraged the French to hope that they could manufacture true china as it was made at Dresden, and kilns on a large scale were built, first at Chantilly and then at Vicennes, and afterwards at the more famous Sèvres. Every pains was taken; an immense establishment was set up, of which the king himself became proprietor, and Madame de Pompadour patronized and did all in her power to encourage the undertaking; but it was not till 1769 that true china was made at Sèvres. Kaolin was found at St. Yrieix, and hard porcelain began to be produced as a manufacture, but unfortunately the processes were imperfect, and the art value of the Sèvres porcelain began to decline just when the material itself began to possess any value at all.

We have said *art value*, but we desire to limit the term to the art value that is represented by money. The soft porcelain of Sèvres of the early period excites the cupidity of the average collector almost beyond every other product of the potter. One, two, or three thousand pounds is no uncommon price for a piece of soft Sèvres, hideous in form, depraved in taste, and with no merit but that of a smooth, rich glaze, a certain correctness and affected prettiness of drawing, and a quite inartistic delicacy of colouring.

The work done by the artists of Sèvres was, even in its most palmy period, intended to win the liking of a dissolute king and a court lost as much to the sense of true art as to any sense of morality, and the result is what might be expected. It is what the French themselves, meaning indeed no disparagement, call "*genre boudoir*," which can please only those who have no higher conception of art than the phrase implies.

Porcelain-making became fashionable when the courts of Germany and the king of France had patronized it. Other royalties followed suit. Charles III. of Naples established royal porcelain works at Capo di Monti, and brought the production of porcelain as far on the road of perfection as it has hitherto been carried in Europe. What is singular about this ware is that the immense difficulties in the way of arriving at even a moderately hard porcelain without the aid of kaolin, were overcome at Capo di Monti as they had never been elsewhere. The ware is neither soft nor quite hard, but the texture is fine, the glaze soft and beautiful, the colouring brilliant, and the art work of a high type. Groups, processions, sea-nymphs, tritons, and marine monsters, and mingling with them representations of natural objects, branches of coral, strings of sea-weed and twisted conch shells, all coloured to imitate nature—these are the characteristics of this remarkable ware, which, though falling somewhat short of the utmost reach of good art, yet comes nearer to excellence than any European china ware has reached before or since. True Capo is rare, and even imitations often fetch very high prices.

The royal patron of these Neapolitan porcelain works carried his workmen to Madrid when he assumed the crown of Spain in 1759. He established a pottery at Buen Retiro, where the traditions of the Capo di Monti ware were preserved, and whose wares possess some of its characteristics.

In the meantime other porcelain kilns had been established at Venice and elsewhere in Italy; the best work, out of all comparison, coming from the manufactory of the Marquis of Ginori, at Doccia. Materials were imported from China, and a true, hard, kaoliniferous ware was made. The enterprising family of Ginori have continued this work until the present day, and the Doccia wares, even the more modern ones, command high prices from their intrinsic art value.[1]

No particular mention need be made of the porcelains produced at the Hague and Amstel in the Netherlands, at Copenhagen, in Russia, in Switzerland, and even in Portugal. The Amstel ware may claim to fall not very short of being second rate, but the others are only curious.

It now only remains to describe the porcelain made in Great Britain. While in nearly every European country porcelain making was patronized, and in some cases actually superintended by kings and princes, in England royal favour was nearly unknown. The Chelsea pottery works indeed were favoured with the penurious patronage of the Court of George II., but no other factory in this country was helped or hindered by royal interference.

It was at Bow that china was, so far as we at present know, first made in Great Britain in about 1740. As in the case of every porcelain manufactured in England except that of Bristol, and possibly some made at Lowestoft, the Bow porcelain was soft. Many reasons have been suggested for the fact that when all the continental potters had left off the fabrication of soft porcelain, the English continued to produce it and no other. The chief reason we believe to have been that the English porcelain establishments were as a rule poor and small; that to adopt the new style required costly plant and materials, and the employment of high-waged workmen acquainted with the new processes;—required, too, the purchase of expensive trade secrets in colouring and in firing. All this would have been beyond the means of the English porcelain makers, who could hardly pay their way as it was. Moreover, the English potters had early learned how to apply phosphate of lime, in the shape of bones ground to powder, to the *body* of their porcelain; the effect of which, while robbing the porcelain of a little of its beauty, is to give strength and consistency to the ware while in the furnace.

The manufactory at Chelsea borrowed its art forms from Sèvres, but its colouring is far less harmonious, its glazes less deep and silky than those of the French soft porcelain. At a later date the Dresden type prevailed at Chelsea, with garlands and bunches of flowers encrusted thickly on the vases. Pastoral subjects, the impossible shepherds and shepherdesses of the period, with their crooks, their knots of ribbon, small waists, and eternal simper, are common to Sèvres, to Dresden, and to Chelsea. The technical superiority was with Dresden, and that of ingenuity and variety of form and ornament, while the glazes and colours of Sèvres were far ahead of its rivals, and Chelsea can only boast of a certain abstinence from the excesses of bad taste prevailing at Sèvres; but to true art-merit not one of the rival potteries can claim the smallest title. The Chelsea manufacture was in no very long time abandoned, as was that at Bow, and the workmen emigrated to Derby, carrying their moulds and their trade secrets and a good deal of their bad taste with them.

The ware made by Cookworthy, at Plymouth, has always appeared to the present writer to be far superior to that coming from the more famous English kilns. Cookworthy, though a Swedenborgian and a believer in the divining rod, was nevertheless a shrewd man of business and a good chemist. His ware, at least the plain white and the blue and white—the most characteristic—is beautifully modelled with natural subjects, shells, sea-weeds, and so forth, and attempting little, is marked by none of the pretentiousness of the period. He had dis-

[1] This supplies an easy mode of distinguishing the soft china. The lower part of each piece rests in the kiln on a small iron tripod, and where not touched by it, is covered with glaze. In true china the heat employed is too great for the use of an iron tripod, and the piece when in the furnace stands on sand; and the bottom consequently has no glaze on it.

[1] At Doccia several wares are produced; a true hard porcelain, and the better known *Terraglia*, a white glazed ware, between porcelain and *faience;* of this, tall vases, statuettes, and even large figures often finely moulded are found in the collections of amateurs. Less praiseworthy, but very successful, are the Doccia imitations of Majolica, Sèvres, and Capo di Monti.

covered kaolin in 1755 near Helstone, in Cornwall,[1] and with it he made hard porcelain. The secret of doing so he sold to Richard Campion, who carried it to Bristol, and there made hard china, which, as collectors know, is in especial favour and demand at the present day, as being the only true porcelain made in Great Britain. A melancholy proof was given of the excellence of this ware on the occasion of the recent burning down of the Alexandra Palace. No fewer than four thousand specimens of old English pottery and porcelain had been lent by different collectors to the palace. The Bow, Chelsea, Derby, Worcester, and other soft wares were reduced to shapeless masses by the heat, but the true porcelain of Bristol, though most of it was broken to pieces by the fall of roof and rubbish, retained its whiteness and even its most delicate shades of colour quite uninjured by the fire.

The porcelain made at Worcester from about 1751 is also in repute; pastoral subjects, tea-drinking parties, not over well executed, imitations of blue and white Oriental ware, and of Sèvres, are characteristic of the earlier Worcester; and almost from the first the Worcester potters introduced the commercially successful, but artistically deplorable, device of printing instead of hand-painting on their wares.

There is still some mystery about some rare specimens of English porcelain stamped at the bottom *Nantgarw*. There is reason to believe that many of the pieces, the *body* of which is, so far as the present writer's experience of them goes, of a singularly fine quality, were painted elsewhere. The ornamentation does not rise above the standard of Derby or Worcester.

At Swansea, porcelain was also made during a short space of time. It is noticeable for its fine painting of natural objects, birds, insects and shells. The painting has often a resemblance to that on Nantgarw porcelain, but the *body* is entirely different; and as the productions of both these kilns are known to have been very trifling in number, they attract large prices from connoisseurs.

With the porcelain of Lowestoft, in Norfolk, we will close our necessarily very brief account of early English China wares. The porcelain of Lowestoft is characterized by a somewhat plentiful use of gilding; armorial bearings are frequent on saucers and plates; flowers and leaves, birds and insects, somewhat conventionally treated; the ornamentation is scanty in proportion to the white ground. The *body* of much of the Lowestoft porcelain is hard—harder than that of any European porcelain that we are acquainted with. The glaze is greenish in colour, and somewhat lumpy in texture, with occasional spots and imperfections; in short, it bears so close a resemblance to the commoner kinds of Chinese porcelain of the period, that it has been supposed that it was imported with the glaze on, and decorated at Lowestoft, a practice which was also followed at Delft. At the neighbouring town of Yarmouth it is positively known that a somewhat similar practice prevailed. The learned Mr. Chaffers, however, contends for the honour of Lowestoft, and maintains that hard porcelain was actually made by the Lowestoft potters. He gives some evidence, but has wholly failed to convince the present writer.

We have endeavoured to describe the characteristics of the products of the different kilns, and more especially those of our own country; a by no means easy task, for the difference, though marked enough in the eyes of the poorest judge, is often impossible to put into words. In doing this, we have said nothing of one valuable means of distinguishing varieties of pottery and porcelain from each other—an acquaintance with the marks which potters have sometimes placed upon their works. We have done this advisedly, and we think that the time has come when some protest should be made against the too great dependence placed by collectors on this means of distinction.

It is, of course, indispensable that potters' marks should be studied. It is proper that our public collections and museums should contain specimens of marked pieces, *with a duly authenticated history attached to each piece*, to serve as a reference, and as settling dates and localities of production. It is well, for the same reasons, that Mr. Chaffers should have written a ponderous and most valuable work on the subject; but it is quite lamentable that any collector should have so little the "courage of his opinions" as to put his trust in a mark rather than in his judgment, and should be ready to give twice as much for a marked piece as for a better one unmarked.

A potter's mark, it must be remembered, is the exception rather than the rule. On the very finest wares they are very rare. Majolica is far oftener than not unmarked. Of "Henri Deux" ware, but one piece has been found with any distinctive mark; Palissy, Persian, and Della Robbia earthenware are hardly ever marked. It is of course far easier to imitate a mark than anything else about a good piece, and spurious marks on spurious pieces abound—are commoner indeed than genuine pieces with genuine marks, as every old collector knows. It is for this reason that we make but small account of this useful but much abused means of distinguishing pottery and china, relegating the information that we give on the subject to a foot-note.[1]

[1] It will have been seen what an important part this substance has played in pottery making. Its technical name is china or Cornish clay, Cornwall being still the chief English site of its production. The mining, or rather digging, for it, and its preparation by washing and drying, form now very important businesses. Immense quantities are annually required, not for use in the potteries only, but in other arts. It is employed to clarify pale ale, and, more or less fraudulently, to stiffen and add substance to cotton and other cloth.

[1] The potters' marks on Oriental china are innumerable, and are even yet but very imperfectly understood in Europe. They refer to the dynasty of the period of their production, or to the name of the potter or of the pottery, and often they contain a verse of high-flown poetry. Only a sinologue and a potter combined could do justice to this subject. Imitations of Oriental marks are often found on the early pieces of Delft and of European porcelain. The marks on majolica are the potter's initials, monogram, or name in full, sometimes the date, sometimes the locality, and oftenest only the title of the subjects depicted. On French pottery, initials and a date mark the earlier pieces of *Nivernais* earthenware; N. standing perhaps for Nevers; P. C. in blue letters; three mullets, perhaps the armorial bearings of the Italian potter, Conrade, and occasionally his signature in full. On *Moustiers* ware, an immense variety of painters' initials in cursive writing, and sometimes the words, "*à Moustiers*," following them. On *Rouen* ware, the same multitude of initials, mostly in upright Roman letters, sometimes an O crossed by an arrow, the mark of the manufacture; sometimes the words "*à Rouen*." On *Dresden*, A. R., or Augustus Rex, in monogram, is the mark of porcelain made in the reign of Augustus, the patron of Bottcher; later on, K. P. M., to signify *Royal Porcelain Works*. The Caduceus is said to be on early pieces intended for sale. The crossed electoral swords were an early mark, and are the best known of all, on Dresden porcelain. With a collector of Saxon china, however, marks go for very little; the sharpness and delicacy of the details and of the moulding are more appreciated. At *Berlin* marks on porcelain are the sceptre, the eagle, and the globe, surmounted by a cross. At *Frankenthal*, a lion rampant; the initials C. T. and a crown belong to a rather later date, and afterwards, when the factory was transferred to *Nymphenburg*, in Bavaria, a shield covered with *fusils*, or diamond-shaped squares, Masonic triangles, &c. The fine porcelain of *Höchst* is distinguished by a wheel, or a wheel surmounted by a crown and cross, in gold, red or blue, according to quality. On *Vienna* porcelain is a shield with a horizontal band in red, or as heralds have it, a *fess gules*. *Fürstenburg* is known by a capital F, in Gothic or Italian character. *Copenhagen* porcelain is marked by three waving lines, to typify the three seas, the Sound, the Great and the Little Belt. The *Sèvres* potters affixed to their wares marks which it is almost an education in French history to master. When the works were at St. Cloud, the mark is S. C., with T. under, for Tron, the manager of the works. The kilns being then transferred to Vincennes, the double L, the cypher of King Louis, was used. After the Revolution the potters were republican, and signed their pieces R. F. (République Française). As political fervour subsided, they signed *Sèvres* only. The mark was *M. Imple. de Sèvres* under Napoleon, and from 1810 till his abdication, the Imperial Eagle. Under Louis XVIII. the double L. again, with a *fleur-de-lys*; under Charles X. a double C. Louis Philippe's reign was represented by a *fleur-de-lys* and the word *Sèvres*, and later on, the cypher L. P. R. F. came in again with the Republic of 1848, and the late Emperor reintroduced the Eagle as a mark, and after 1856, the Sèvres potters adopted the Imperial N. *Amstel* is marked by a capital A., or its own name, alone or accompanied by the letters M. O. L., signifying, *Manufactory of Oude Loostrecht*, the works having originally been there situated.

These are all the chief marks on foreign productions. At home the earliest marks are the C. and the broad arrow-head in brown on the cream-coloured earthenware of *Leeds*. *Elers'* ware has the makers' name sometimes stamped on it. The usual spurious Chinese marks are found on the earthenware imitations of Oriental porcelains. *Wedgwood* used no mark except occasionally his name impressed, and the reign of marks did not commence till the porcelain makers began. On *Bow* china it is doubtful if any mark was habitually used. The very earliest Chelsea appears to have had no mark; afterwards a stamped triangle marked the productions of the Chelsea kilns; a raised oval containing an anchor; an anchor and dagger painted red; afterwards the anchor alone, sometimes red, sometimes gilt, the gilt on the best pieces. It has been noticed that the *Venice* porcelain is likewise anchor-marked, and some connection between the two works has been conjectured but not proved. Early *Derby* is known by a D.; when the Chelsea factory was amalgamated with that of Derby, the Chelsea anchor was crossed with the D., which stood for Derby, and this porcelain is known as *Chelsea-Derby*. Afterwards the anchor was left out, and a crown, with a St. Andrew's cross set over it, was used, the ware thus marked being called *Crown-Derby*. *Plymouth* is often marked ♃, the symbol for Jupiter, and for the metal tin. Perhaps Cookworthy desired to notify

The extent of our subject and our want of space compel us to dwell only very slightly on the aspects of the art of pottery of the present day. We do not regret our inability to do more, for if there is much to say in praise of the progress of this art in late years, there is also much room for adverse criticism. For the first twenty years of the present century, hardly any vitality showed itself in pottery-making. The Exhibition of 1851 allowed the world to perceive that some little activity had already begun in the French and English art potteries. There had at that time arisen that revival of truer art feeling in this country which the critics and artists absurdly called "Pre-Raphaelitism," and nearly smothered in its germ by making ridiculous. This singular latter-day Renaissance preceded by a year or two the introduction of an art element into our potteries, where it had long been absent. The bettering of our fictile products has continued ever since. The French and the Italians have also advanced far, but the traditions of Sèvres and mediæval Italy and their ancient glories have seduced them into wrong paths.

Deck and one or two other admirable French artists in pottery have successfully imitated some of the single colour kaolinic glazes of China, and such a feat as this does not lie open to the objection common to other sorts of imitation.[1] They are reproductions or rediscoveries of secrets lost to the Chinese themselves, not a servile copying of a particular style of art. At Gien, near Orleans, a large manufactory has reproduced, at almost nominal cost, the best wares of Rouen and the old French *faiences*. The cheapness and the serviceableness of the Gien ware almost redeem the fault of its origin.

The merit of having advanced the potter's art further than it has been carried in Europe since the days of the Renaissance is due to our own countrymen. They are at this moment pre-eminent among European potters, not in the making of artistic ware only, but also in the manufacture of cheap and useful crockery. Our common English earthenware undersells the products of every country where it is allowed to gain admittance, while our decorative pottery is quite as indisputably the best in Europe.

The one thing wanting with us—rather, the one thing not abundant—is invention. This has led our people to divert their technical knowledge and capacity into imitations. The Majolica and Palissy wares have been travestied rather than copied, and English potters have not even feared to attempt to imitate the quite inimitable *faience* of "Henri Deux;" but our great potters have done worthier things than these, and much admirable and even original art work is annually turned out from their kilns.

Painting on *faience* plates, dishes, and *plaques* is perhaps the direction in which our English pottery art is likely most to excel. That this branch of the art should not degenerate will depend as much upon buyers and the public as upon the artists themselves. If the public will school itself to see the truest merit in a quiet, harmonious scale of colouring, in flowing lines, in simple subjects not over elaborated, in a broad treatment of light and shadow—in short, in a style suited, as all true styles should be, to the exigencies of the materials employed—then we may hope that the painters will give up a certain forcible, jaunty, flashy mode of decoration, with gaudy, garish colouring, which has begun to prevail, and that British pottery will continue to hold its present supremacy.

to adepts that he used tin in his glaze. *Bristol* porcelain has a cross. The commonest marks upon *Worcester* are a crescent, a W., a square filled with chequers, and imitations of Chinese marks, besides innumerable others. On *Swansea* we have a trident, and the word *Swansea* stamped; and on *Nantgarw* that word similarly impressed.

[1] These French re-discoveries, the work of scientific chemists, as well as potters, are very far ahead of the achievements of our potters in the same line. The turquoise blue of Deck might almost be taken for the true Oriental colour, so pure is it, so delicate, and the glaze so brilliant. The single colour glazes of the English potters are comparatively dull in the glaze, and crude in their tone of colour. They do not seem to have considered that to produce their depth and brilliancy, the ancient potters employed materials that would only vitrify at an intense heat. It is a maxim in pottery that the stronger the fire the brighter the glaze, but also the greater the difficulties. The imperial red, yellow, blue, and black of China are always on stoneware *body* with a crackle glaze; and this sort of glaze can only be produced by an excess of kaolin and a strong fire. All the above colours are now more or less successfully reproduced by the potters of Europe except the red, and the secret of this splendid colour has, we have reason to believe, been at length discovered by an English potter.

## IRRIGATION: A FEW PRACTICAL NOTES ON ITS WORKING DETAILS.

THE necessities of an increased and an ever and a rapidly increasing population have of late and are now giving specially marked prominence to all schemes by which the fertility of the land can be increased, upon which so much depends for the raising of our food, whether that be in the form of "crops" or of "cattle." And not only so with reference to those lands already under cultivation, but also with reference to those which, known by the term of "waste," have given rise to much, and as yet mainly, if not altogether, unprofitable discussion. Much of this unfortunately negative result may, and has, we fear, arisen from the ignorance of many of the practical details of the subject, by those who have entered upon this discussion; this ignorance giving rise not merely to an exaggerated estimate of the extent of the waste land throughout the kingdom capable of improvement, but also to the no less exaggerated views as to the ease and also the economy with which these waste lands can be brought into cultivation and maintained in a high state of fertility. While, therefore, it may be accepted as a truth that a wide area of waste lands exists which can be cultivated with profit, it may no less be accepted as a truth that there are some of them about which this cannot be said with any reasonable hope of its ever being realized. But nevertheless the fact remains that of the lands now under cultivation it may be said, and this without fear of contradiction even from those who belong to the class who maintain that whatever is is right; that a large percentage of them are still capable of being so far improved that they could yet bear larger crops of produce; or maintain more extensive flocks of sheep, or herds of cattle. And further, that of the wide tracts of waste land at present lying wholly unproductive, a large percentage could be brought under profitable cultivation by the expenditure of sums not difficult to be raised by a people whose spare cash—and cash not easily to be spared—is too often engulfed in the thousand and one schemes which, being of a somewhat "airy" nature, are, in appropriate enough terms, stated in the daily papers to have been "floated" in the market, and of which not a few of them are destined to be "sunk," taking with them the hard-earned gains of the saving and the prudent, no less than the more easily attachable funds of the scheming capitalists who are ever ready to "go in"—as the phrase is—for any thing. Amongst the powers at the command of the farmer by which the fertility of land at present under cultivation can be increased, and waste lands brought into cultivation, irrigation may be named as one possessed of no small value. Although of this value there is but one opinion amongst authorities, it is a somewhat curious and suggestive fact, that it is one which is by no means so readily and largely availed of, as it might be, and as, we unhesitatingly say, it ought. It would, did space and time permit, open up some practically useful points to enquire why this should be; enough for our purpose to draw attention to the fact that it is. Indeed it may be said, that so far from being on the increase, irrigation is less practised now than it formerly was, this holding true of countries other than our own. But it is on the other hand gratifying to know that an increased and increasing attention is being given to the subject, and it is to be hoped that before long, lands, which at present are in every sense of the term "waste," will be covered with the grass which "yieldeth food for cattle," or waving with the corn which "giveth strength to man." Amongst the ruling motives which may bring this much-desired consummation about, may be classed that which has its outcome from the attention which is being given to that much-talked-of, much-written-about subject, the "utilization of town sewage." This subject is one of such vast importance, and carries with it so many considerations of such immense value to us nationally, that it invites, and may, in a future number of the magazine, obtain from us that thorough investigation into its details which it deserves. It is enough for us for the present, to state that it is closely connected with the subject of irrigation. So closely, that it may be said of it that in some instances the benefits which have been undoubtedly derived from the application of town sewage to land by the medium of irrigation owed much of their existence to the advantages derivable from irrigation *per se*; that is, that it was a matter of comparatively easy proof that much of the benefits which the land had derived from the application of town sewage by irrigation would have, at least to a large extent, been obtained had water—and not town sewage—alone been used. We name this, not with a view of provoking discussion upon a point which we may be inclined to admit as readily as the most enthusiastic

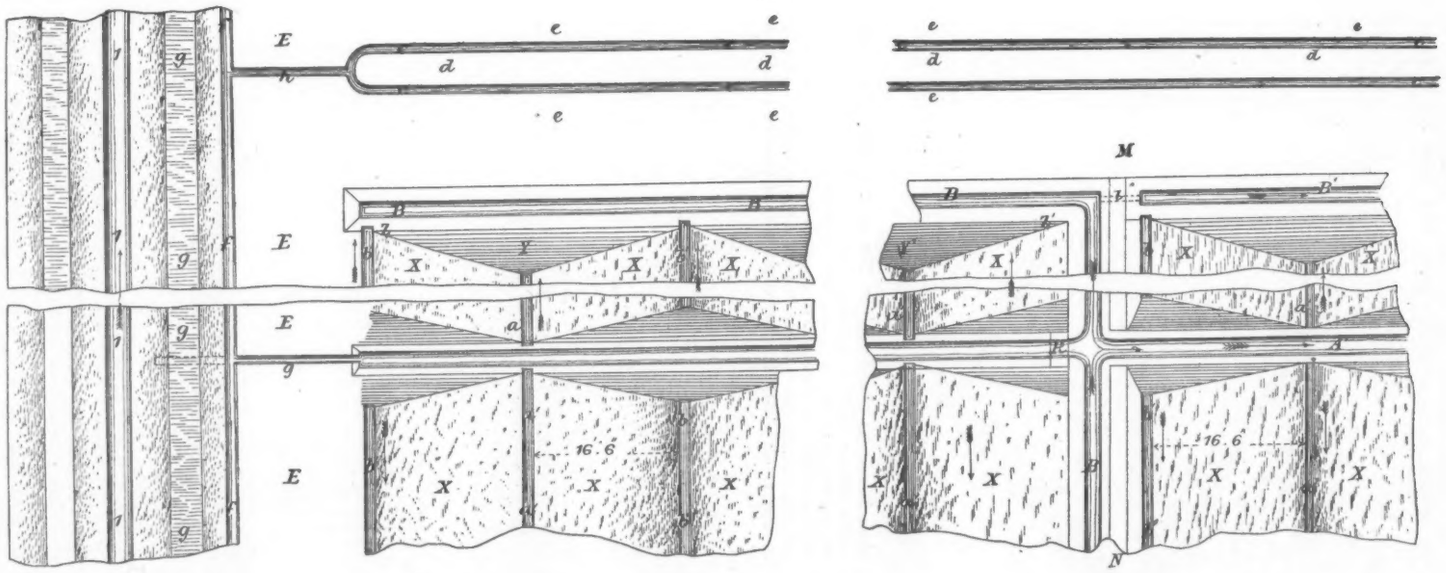



Fig. 2.

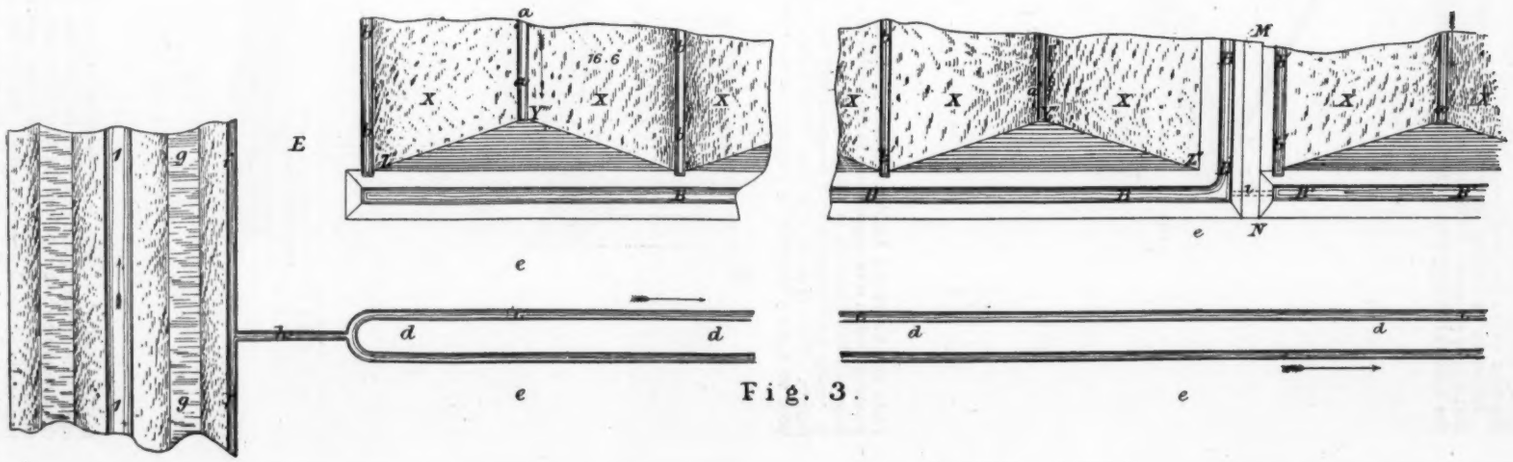



Fig. 3.

advocate of "town sewage utilization," but rather to show how closely connected the subject of our present paper is with that of the most widely discussed topics of the day.

Irrigation, as already hinted, has been so largely practised, that it is by no means a difficult matter to gain information as to the benefits resulting from its application. But marked as have been the benefits in districts in this country, we have but to cross the Channel to find in the rich and fertile fields of our continental neighbours what irrigation can do alike on the smallest, and on the largest scale.

Mr. James Howard, the well known agricultural engineer of Bedford in his admirable paper, read some two or three

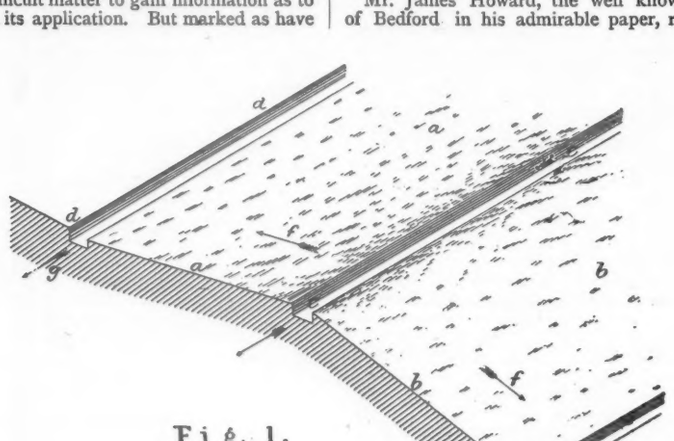



Fig. 1.

years ago before the London Farmers' Club, on "Continental Farming," refers with approbation to the beneficial effects which irrigation has exercised in various districts of the Continent in raising the cultivation to a comparatively high state of perfection. There is perhaps no part of the Continent which has been so signally benefited by irrigation as that district of Belgium known as the Campines, the most interesting part of which can be reached in a few hours from Antwerp by taking the railway to Turnhout. The traveller, as he journeys on towards this town, will pass through a country which, in its general aspect, presents to him at once the features of a spare, barren, and wild sterility rarely equalled in any of the wildest districts; and of a

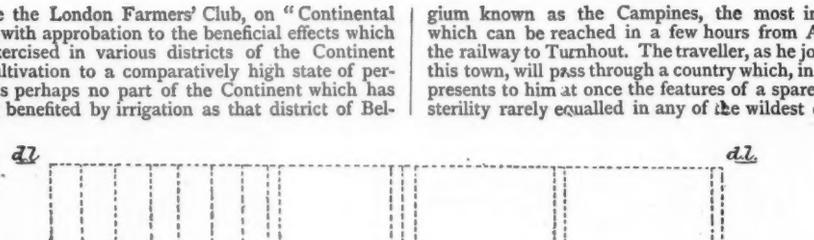



Fig. 4.

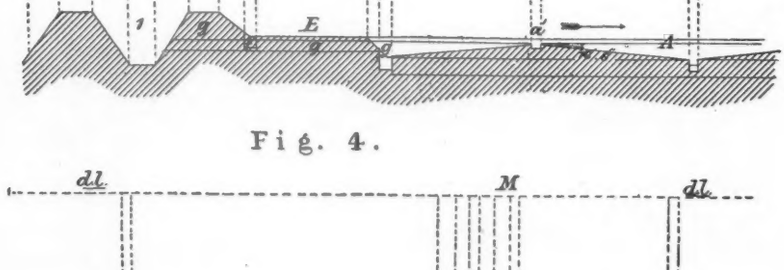



Fig. 5.

fertility singularly striking in its beauty even to an unpractised eye. The sterility illustrates what the condition of the land throughout nearly the whole of the district was once, and in large tracts still is; the fertility that which it is fast presenting under improved and improving cultivation. On one side one will see nothing but sand, so light that it is driven into heaps, or scattered like snow-drift before the wind, with here and there only stunted shrubs and patches of heather and wild flowers; on the other will be seen waving corn, or green grass, and all the evidences of abundant fertility. One great cause of the change which has taken place in large measure, in the condition of the soil, and which is daily extending, is the system of irrigation which has been so carefully and extensively carried out in the province. It will be, therefore, of some practical utility if we glance briefly at the general features of the systems there employed. There are many methods of irrigation employed, but the first we shall describe is similar in its features to that known with us as the "ridge-and-furrow" system, in which

the land is divided into a series of sloping surfaces *a b*, fig. 1, over the surface of which the water is shed or distributed from the gutter *c*, and taken up by the gutters *c d*. Great skill is shown in the setting out of the land to be irrigated on this method; and in working so that the soil taken out from the cuttings shall be used to the best advantage in the embankments or raised parts forming the sloping surfaces *a b*, fig. 1. The land is laid out into compartments some seventy or eighty feet long, the length of these being in the direction of the general slope of the land.

Before giving the practical details of management of an irrigated district, or of many of the points connected with the laying out and construction of the parts, it will be best to present our readers with the working plans and sections of a field laid out on the system as practised in Belgium, these being taken from a report on the subject by Mr. T. Keelhoff, engineer in charge of the service of irrigation of the Campines. Fig. 2 is the plan of the upper part, and fig. 3 of the lower part of the field (our space not permitting of the giving of the plan in full). This, as will be perceived, is laid out in lengths angular in sec-

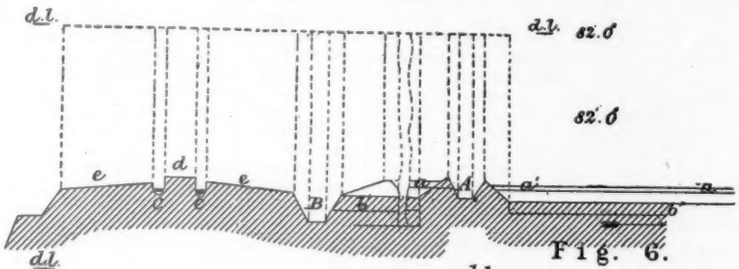



Fig. 6.

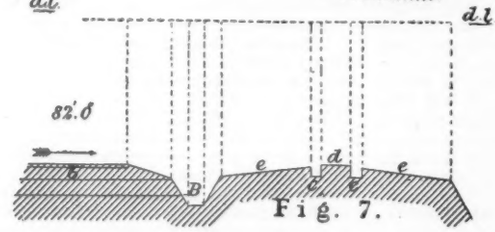



Fig. 7.

tion, as shown in the transverse section in figs. 4 and 8. Of these angular parts *a' a'* is the apex, along which the channel for leading the water is placed; this overflowing, flows down the sloping sides in the direction of the arrows *f f* in fig. 1, and is received by the channels *b' b'*, figs. 2 and 3. The channels all lead into the large drain or watercourse B B. The channels *a a* at the top of the ridge receive their supply from the watercourse A A, fig. 6, which runs at right angles to them. The whole field is divided into "compartments," in each of which there are five of the ridged parts, so to call them, as *a b c d e*, fig. 1, and each of the compartments is divided from the other, so that each can be irrigated independently of the other. To aid in this, a small sluice is made at the point R, see fig. 2. The "compartments," each of which, as above stated, comprises five of the ridged parts, as in fig. 1, are placed so that the length of the channels, as *a' a'*, fig. 2, runs transversely to the general inclination of the whole field, so that the channels A A and B B have a gentle flow or inclination throughout their length. It will be observed on inspecting fig. 2 that the channel B, which receives the water flowing from *a' a'* over

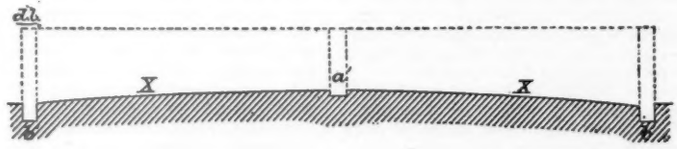



Fig. 8.

the sides of the ridged part, bends round and flows between the two compartments, and then delivers its water to the channel A', fig. 3, which thus is the channel of supply for the channels *a' a'* of the ridged parts of the second compartment. A small sluice is placed at the bend of the channel B at the point *i*, fig. 2; the main source of supply of the channels A A is the large drain or channel at *g g*, which runs at right angles to *a a* and parallel to *a' a' b' b'*. Fig. 4 is a section of fig. 2; fig. 5 of fig. 3, on a line parallel to the channels *a a* and at right angles to the ridged parts *a' a' b' b'*. Fig. 6 is a section in a line at right angles to the channels A A, or along the length of the ridged parts *a' a' b b*, and of the upper end of the field of which fig. 2 is the plan. Fig. 7 is the section of the lower part of the field plan in fig. 3, and fig. 8 is a cross section of one of the ridged parts. The general dimensions in French measurement (see a paragraph in "The Practical Note Book," which will be given in a succeeding number of this journal): the length of the ridged parts is 25 metres (a metre is 3 feet 339 inches); the breadth of one of the sides of the ridged part, as *c d*, is 5 metres. The width of the channel *a' a'* at the top of the ridge is 25 centimetres, the depth 6·05 centimetres. The width of the channels *b' b'* 25, and depth 20 centimetres. The width of channels *a a* 50 centimetres (half a metre) at the bottom (they have inclined or sloping sides, as shown in section, fig 6) and 1 metre at the top; the depth is 25 centimetres. The channels B B have a width at bottom of half a metre, at top of a metre and a-half, with a depth of half a metre. The width of the slopes *e e*, figs. 6 and 7, is 3 metres. Some of the leading dimensions we have given approximating to our own measurements. In our next we shall resume the subject, giving more fully the details of construction.

THE following figures give the quantities of coal raised in Great Britain, with the loss of life which took place for each year, from 1868 to 1872 :—

| Date. | Tons of Coal raised. | Deaths. | Tons of Coal raised per Death. |
|---|---|---|---|
| 1868 | 104,566,959 | 1011 | 103,429 |
| 1869 | 108,003,482 | 1116 | 96,777 |
| 1870 | 112,875,525 | 991 | 113,900 |
| 1871 | 117,439,251 | 1075 | 109,246 |
| 1872 | 123,393,853 | 1060 | 116,400 |

The chances of a collier's life may thus be accurately calculated according to the quantity of coal raised, the ratio being closely preserved year after year with dreadful regularity.

## ON THE MINERAL RESOURCES OF NORTH CAROLINA.

By Frederick A. Genth.

FOR a long time past the State of North Carolina has been noted for its great and varied mineral wealth, hence it became the favoured field for speculations of every sort, some of these of the wildest character. It is not, therefore, to be wondered at that failure should have met most of those schemes, which contemplated mere stock operations in place of a legitimate development of the mines. However, as an unfortunate consequence of those speculative undertakings, an impression has been cast in our northern cities to the effect that the mineral riches of that state were more imaginary than real. The fallacy and injustice of such a conclusion were fully demonstrated to me twenty years ago, during a residence of nearly two years in the state, and since that time my faith in the mining resources of North Carolina has been strengthened by frequent visits as an expert, during which I have examined most of the gold, silver, copper, lead, zinc and iron mines of the central counties. In addition to those many opportunities of acquiring positive evidence of the mineral wealth of that state, it was my good fortune to spend a great part of last summer in North Carolina in company with Professor W. C. Kerr, the very able state geologist, at whose request I visited the principal mineral localities of the state for the purpose of working up the mineralogy for the geological report. My field for examination has been quite extensive, embracing, more or less, about thirty-two counties of the state.

As one of the results of the geological survey of North Carolina, it may be interesting here to state that it has already contributed to the development of several mining localities, which have invited the attention of northern capitalists; other mining properties are in process of negotiation, and I have no doubt that, when better known, many other mines, which at present are neglected, will command the attention they justly deserve, offering, as they do, inducements for safe and profitable investment.

Athough my labours in North Carolina in connection with the geological survey were generally directed to the mineralogy of the state, I have nevertheless made numerous observations, and acquired many facts which may be interesting to the members of the Franklin Institute. I intend giving a brief account of the vast mineral resources of North Carolina, but ere I describe the occurrence of the different ores, it may not be amiss to sketch, in a concise way, the general outline of the geology of that state, without, however, entering into a geological discussion with reference to the position and age of the various rocks, but simply coninfing myself to their petro-graphical determinations.

Almost the whole state of North Carolina is made up of gneissoid or granitic rocks, alternating with strata of argillites, quartzites and talcose, chloritic and micaceous slates, all more recent rocks, resulting from the destruction of the older.

These are overlaid, in its eastern and south-eastern portion, for a distance of from ninety to one hundred miles from the coast, by tertiary and cretaceous deposits, with numerous marl beds, of much local importance for the agricultural development of this portion of the state. Many of these beds contain small quantities of lignite and pyrite, but not in sufficient quantities to be of any commercial value.

The older formations are arranged in nearly parallel bands or belts, which cross the state in a north-east to south-western direction. The tertiary and cretaceous formation rests immediately upon a belt of quartzites and slates bearing N. 25—30° E. with a south-easterly dip, and these are underlaid by granite and gneissoid strata, which border them on the west and form the most eastern granite belt, known as the Raleigh belt, which occupies the greater portions of Warren, Franklin and Wake counties, with Raleigh as a centre; and extends from there south-westwardly through Richmond county into South Carolina. It consists, to a large extent, of a granular granite, composed principally of orthoclase, greyish white granular quartz, and very little mica, which is frequently biotite. In many places the granite is a real granulite; in others it graduates into gneiss, and here and there into hornblendic strata.

The Raleigh belt is overlaid by very extensive beds of slates, argillite, quartzite, etc., with a north-west dip, traversing Granville, Person, Orange, Alamance, Randolph, Moore, Montgomery, Stanley, Anson, Union and the south-east part of Davidson, Cabarrus and Rowan counties.

To the west of these slates, which have been called *taconic* slates by Emmons, another band of the oldest rocks is again observed. It has been called the Greensboro' and Salisbury granite belt, and occupies the principal portion of Caswell, Rockingham, Guilford, Forsythe, Davie, Davidson, Rowan, Iredell, Cabarrus, Mecklenburg and the eastern portion of Gaston, Lincoln and Catawba counties. The granites are often granulites, consisting only of orthoclase and quartz. In many places they became porphyritic, by the dissemination of large orthoclase crystals throughout the mass; again they change to gneiss and mica schist, and frequently, through a gradual admixture of horn-blende, they turn to cyenite, hornblendic gneiss, hornblende slates and even diorite. These hornblendic rocks are interlaminated with the granite and gneiss, and their gradual passage from one into the other are evidence of their contemporary origin. As these hornblendic or dioritic rocks are less readily decomposed, they often form vein-like walls through the other rocks, so-called "trap-dykes," and as the result of their partial disintegration, the surface is covered with rounded boulders.

Accumulations of various iron ores, hematites and magnetites, form bands in this belt of gneissoid rocks.

Another band of more recent slates, characterized by several important beds of limestone and magnetic iron, passes from Kings Mountain in a north-easterly direction through Gaston, Lincoln and Catawba counties; here it is interrupted, but it occurs again in Davie, Forsythe, Yadkin and Stokes counties.

Proceeding in a westerly direction, we again come into the region of the oldest gneissoid and related rocks, very similar to those of the more eastern belts. These make up the bulk of the counties of Wilkes, Caldwell, Alexander, Catawba, Cleveland, Burke, McDowell, Rutherford, Polk and Henderson.

A narrow band of slates borders this granite formation through Surry, Wilkes and the north-western corners of Caldwell, Burke, McDowell, Henderson, and passes through Transylvania county into South Carolina. These slates appear to be connected with those of Stokes county. In this band of slates in several localities there occurs a peculiar quartzite, which, by a minute admixture of mica between the rounded particles of quartz, forms the so-called "flexible sandstone" or itacolumite. The principal localities in which it has been observed are Linville in Burke, Bending Rock Mountain in Wilkes, and Sauratown Mountains in Stokes counties. In this narrow belt of slates, several valuable limestones and iron ore beds have been discovered.

The last belt of the gneissoid or granitic rocks occurs west of these slates. It is largely made up of gneiss and hornblende slates, with a frequent admixture of garnets and crystals of cyanite. These rocks occur in Alleghany, Ashe and Watauga counties; they are interrupted, however, in the southern portion of the latter and the northern part of Mitchell county by a narrow strip of slates, which extends into Tennessee; but they then continue through Mitchell, Yancey, the greater portion of Madison, Buncombe, Haywood, Jackson, Macon and Clay counties, and the south-eastern part of Cherokee county. In this belt large veins of granite occur, with massive accumulations of orthoclase and muscovite, associated with garnet, tourmaline, beryl, &c.; also lenticular masses of magnesian rocks with chrome ores, either chloritic slates, &c., or granular chrysolite, which is the parent rock, by the alteration of which, in Pennsylvania, for instance, the serpentines have been produced. The extreme north-western limits of the counties of Mitchell, Madison, Haywood, Jackson, Macon, and the greater portion of Cherokee, are again occupied by slates, frequently enclosing beds of marble and granular dolomite interlaminated with beautiful talc slates or micaceous slates, containing large crystals of staurolite, garnet, &c.

I have yet to mention as a very important formation the "triassic," which occupies a portion of the central counties of North Carolina. Resting upon Emmon's so-called taconic slates, narrow bands of shales and sandstones pass through Granville, the eastern edge of Orange and the western of Wake county, which in Chatham and Moor counties widen and contain several valuable beds of coal; the formation continues through the south-east edge of Montgomery, thence through Anson county into South Carolina. The dip of these strata is south-east, and they form the south-eastern portion of the triassic formation, the central portion of which has been removed by erosion, whilst the north-west portion, with a north-westerly dip and resting directly upon gneissoid and granitic rocks, appears again in Rockingham and Stokes counties, where it shows sandstones, shales and numerous outcrops of coal beds.

The gneissoid or granitic strata, as well as the slate formation, are frequently intersected by metallic deposits, either in veins and associated with quartz as a vein rock, or in ore beds, interlaminated with the strata, and forming a portion of the formation.

I will now proceed to the consideration of the occurrence of the different metals and other valuable minerals :—

*Gold.*—According to the earliest records the first piece of gold found in North Carolina was picked up in 1799, in a little branch at the Reid plantation, Cabarrus county. It weighed between three and four pounds, and was kept several years without its real character being suspected ; subsequently, it was sold to a jeweller in Fayetteville for 3.50 dollars. When its true character became known, search was made for more, and fourteen lumps, weighing in the aggregate 153 lbs. troy, were obtained at the same locality.

The gold veins and gravel deposits were afterwards discovered ; and for a considerable time gold operations were conducted in many localities on a comparatively large scale. The discoveries of gold in California, where a far richer harvest was promised, led to the abandonment of many of those enterprises ; other causes have also influenced in the same direction, as, for example, the difficulties connected with deep vein mining, and the impossibility of extracting the gold by the imperfect and slow machinery then principally in use, the Chilean Mill and Arastra, &c., from heavy ores like pyrite, &c., which nature has not already decomposed. With the exception of minute quantities of telluride, in the very rare mineral nagyagite, at the King's mountain mine, gold in North Carolina is always found in the metallic state. It is rarely quite pure, but generally alloyed with more or less silver. It occurs in crystals or crystalline masses, in thin plates or laminæ, between the foliation of the slates or through associated minerals, such as quartz, pyrite, galenite, zinc-blende, &c., in such a fine state of division that it is generally invisible to the eye.

It has been observed in four different geological positions :—

1st. It is met with in the mass of the gneissoid, granitic and hornblendic rocks.

2nd. In quartz veins, often associated with pyrite, chalcopyrite, galenite, tetradymite and other minerals.

3rd. In ore beds, cotemporary with the strata of rocks in which they are found, as in chloritic and talcose slates, argillites, quartzites, &c.

4th. Loosely in the soil and decomposed rocks, especially in gravel deposits, resulting from the destruction of the above first three formations. One of the most remarkable features peculiar to the rocks of the Southern States is their rapid disintegration.

The *débris* from these rocks, forming the soil or ferruginous clay, remains *in situ*. This disintegration is frequently observed to a depth of over one hundred feet. Many of the railroad cuts show beautiful sections, and the study of these exhibits some highly interesting features, which I shall mention, as they are of the greatest importance to a full comprehension of the subject.

In many places cuts may be seen which appear to have been made in a uniform mass of clay, which, in general, is ferruginous ; on close observation, however, it is easy to recognize that the apparently uniform clay stratum belongs to two distinct formations.

Immediately below the soil, which may be covered by vegetation, the ferruginous clay will be seen to contain, here and there, small fragments of quartz in angular pieces, with the edges more or less rubbed off, disconnected and not occurring in regular seams or veins ; the number of those quartz pebbles gradually increases at a greater depth, until they form a regular stratum of gravel.

Some of those gravel beds are hardly perceptible ; others vary from a few inches to over 30 ft. in thickness.

When the great denudation took place, these fragments of quartz deposited themselves upon the then unaltered bed rock—the granite, gneiss, mica schist, slate, &c. ; but after this period the disintegration of the rock continued, and it is natural that the same kind of clay should have resulted from the same parent rock.

Therefore we find, just below this gravel bed, ferruginous clay as above, but a closer investigation shows a great difference, and especially two striking facts ; in the first place, the stratification can be observed and followed to the underlying, undecomposed rocks ; and, secondly, the quartz, which is found in the same, occurs not in loose angular pieces, but in regular seams or veins, in their original position.

In some of the auriferous regions of North Carolina, such quartz veins are very numerous ; in others, they are less frequently met with.

Most of them are exceedingly small, varying in width from the thickness of a knife's blade to a few inches, and often extending in depth but a few feet ; some bulge out and form nests or pockets in the rocks, while others again are of enormous size, and are known to exist as deep as they have been developed, which, in a few rare instances, is down to 200 to 300 feet.

Many of these quartz veins are in reality beds, as they coincide in strike and dip with the stratification, whilst an equally great number run in every conceivable direction, and dip just as irregularly.

The greater portion of these quartz veins contain no gold, or only such a small quantity that they could not be profitably worked, especially the large veins of vitreous and milky quartz.

Many of the small veins, principally those which contain granular or saccharoidal quartz, are rich in gold.

Some of the large veins, especially those containing much cellular quartz, have frequently been found to be the most productive. This cellular quartz results from the decomposition of pyrite, which once occupied the now empty spaces ; leaving them either occasionally quite free from iron, or more generally rusty, and more or less filled with limonite. These, the so-called brown gold ores, are the best, and most easily worked. At a greater depth of the veins, where the pyrite is not decomposed, the gold is so much mixed with heavy sulphurous ores, that, with the present system of operations, it cannot be extracted with profit ; in many cases the gold disappears entirely.

Most of these gold veins in North Carolina were abandoned, when the iron and copper pyrites increased too largely, and before they had been wrought deep enough to contain copper ores in paying quantities.

The gold in these mines is not evenly distributed through the mass of the gangue ; the veins often contain entirely barren portions alternating with rich ones, the latter called shoots of ore or chimneys.

Such shoots are in reality veins inside of a vein, and are frequently quite regular in their dip ; the ores at the foot wall are generally richer than those at the hanging wall.

Many gold mines of this description have formerly been worked, and many of them undoubtedly are still of great value.

In Guilford county, there were the McCulloh and Fisher Hill mines ; in Cabarrus county, the Phœnix, Vanderburgh, Cullen, Pioneer Mills mines ; in Mecklenburg county, the Capps, McGinn, Rudesill mines ; and numerous others. At present, almost every one of them are unworked ; some explorations are carried on in Cabarrus county, and in Mecklenburg county the McGinn and the Wilson mines are the only ones in operation, and that on a small scale only.

At the McGinn mine they have a 5-stamp battery and amalgamated copper plates, also roasting ovens to decompose the sulphides ; at the Wilson mine there is a 10-stamp battery with amalgamated copper plates, all after Californian patterns.

Many of the quartz veins in the slates, differing in strike and dip from the enclosing slate, carry gold, especially those which contain cellular and cavernous quartz, associated with limonite, hematite, siderite, pyrite, chalcopyrite, &c.

Some of them are highly promising, as, for instance, those of the Conrad Hill mine, in Davidson county ; but, unfortunately, not a single vein has been sufficiently developed in depth to form a just appreciation of its value.

The gold deposits, which are cotemporary with the slates themselves, are of far greater importance than the true gold veins.

The talcose, chloritic, micaceous or arenaceous slates in which they occur, contain portions which are more or less charged with gold. The gold in these slate beds, like the slates themselves, is derived from the destruction of the older rocks, and has been deposited simultaneously.

The width of these auriferous beds varies from a few inches to from 60 to 70 ft.

The gold in them is often found without any admixture, and the auriferous strata shows no line of demarcation, and cannot be distinguished from the barren layers ; but, generally, and subsequently to its deposition, it has been acted upon by chemical agencies, dissolved and precipitated again, and has assumed a crystalline structure ; it has accumulated in strings which sometimes form lenticular and more highly auriferous masses in the beds, and is associated with crystalline quartz, pyrite, chalcopyrite, galenite, blende, mispickel, &c.

These are often parallel with the slates, and so close together that they can be worked by the same operation, especially where the slates between are also auriferous.

The Steel mine, in Montgomery county, and the Stewart mine, in Union county, are examples of this occurrence.

These gold mines have proved to be the only reliable ones in depth, and, if they are found to be rich enough for working, they can be depended upon for the future.

To this class belong the mines at Gold Hill, in Rowan county, which have already produced not less than 2,000,000 dollars, and have reached a depth of 750 feet. Although this appears to be a very large production, I do not hesitate to say that perhaps four-fifths of all the gold in the ore, which is a talco-micaceous or chloritic slate, intermixed with pyrite, magnetite

and a little quartz, has been lost in the tailings, on account of the very imperfect process used for the extraction of the same.

The King's Mountain mine, of Gaston county, also belongs to this class. The gold is, to a great extent, contained in a quartzose limestone, and is associated with very small quantities of pyrite, galenite, chalcopyrite, but also with the very rare tellurides of lead, altaite, and with nagyagite, a telluride of gold and lead.

In some places this ore bed is over thirty feet in thickness, and has been worked to a depth of 200 feet, but longitudinally only to a very small extent, not over 250 feet.

This mine is also said to have produced over 1,000,000 dollars. The machinery used for the reduction of the ores are a twenty-stamp battery with amalgamated copper plates, &c.

There are at present no other mines belonging to this class in operation, but there is no doubt that Montgomery, Union, Stanley, Rowan, Davidson, Randolph, Gaston, and Cherokee counties have many localities, where profitable and successful mining operations might be carried on.

In gold mining operations, the deposits which result from the disintegration of the rocks, and subsequent denudation, are undoubtedly of the greatest importance; there the gold which was contained in the rocks and in the small auriferous veins (which have been broken up into fragments) has been concentrated by nature, and in many places has been deposited, with the remnants of the veins, in the gravel beds, which I have already mentioned.

Those gravel beds occur to a greater or less extent throughout the whole gold region; the oldest gneissoid rocks as well as the slate formation contain them.

The quartz in general is not water-worn, only the sharp edges are rounded. Many pieces still present the shape and thickness of the veins whence they came.

The most extensive gravel deposits exist in the South Mountains, on the headwaters of the first and second Broad River, Muddy Creek and Silver Creek, in the counties of Rutherford, McDowell, Burke, Caldwell, also in Polk, and Cleveland; embracing an area of over 200 square miles.

They appear to cover the greater part of the land, rise often to a considerable height on the slope of the hills, but are naturally more concentrated in the bottoms and flat lands. The gravel beds in this region vary in thickness from a few inches to thirty feet, and are covered with soil and clay, which is also more or less auriferous, although much poorer than the gravel beds below.

These deposits have been worked since about 1830, and before gold was known in California many thousands of hands were at work digging and washing in a rude way, yet many millions of dollars were produced without the help of any complicated machinery, and without the knowledge of a proper use of water.

Since that time very little has been done; in some instances the old gravel was worked over again, and has made fair returns to the adventurers.

Very large tracts of land, containing extensive and valuable deposits, have never been touched, and, by the introduction of the Californian hydraulic system of operations, a safe and very profitable business could be carried on.

The gold is rarely found in nuggets; generally as fine dust and in small grains. Its fineness averages about 825 thousands. It is associated with numerous interesting minerals, such as platinum, diamond, zircon, xenotime, monazite, and many others.

Experiments with vein-mining in this region have not proved successful; the rich veins are too narrow in width, and of too limited extent in depth, and the large veins do not contain enough gold to be advantageously worked.

A small region of valuable gravel beds exists in the gneissoid rock and micaceous slate of Franklin and Nash counties, in the eastern part of the State. It has been most extensively prospected at the Portis mine, where it is very rich, and has been worked since about fifty years, having produced, it is said, over 1,000,000 dollars.

The productive gravel is here the result of the disintegration of numerous small granular or sugary quartz veins, and very fine specimens of gold in such quartz are frequently met with.

The fineness of the Portis mine gold was generally about 985 thousands.

There are enormous gravel piles at the mine—the remnants of former operations.

Some very important but expensive experiments have been made at this mine.

Machinery was here erected for crushing and amalgamating the gravel, which, being part of gold veins, was thought could be profitably worked for gold.

The result was precisely what my own examination of the place convinced me it should have been—*a failure;* because, whilst the gravel may contain some very rich specimens, the whole bulk is too poor to be worked with profit. This is accounted for from the fact, which I have already intimated, that the gold in the gravel deposits, principally, is the *loose* gold, which had existed in the rocks and between their laminæ, or that from the *small* quartz veins, whilst the large veins are mostly *barren.* In a region which contains many small veins, the gravel deposits are generally valuable, even if the bulk of the beds has been made up from the destruction of large ones.

There are several highly important gravel deposits in Montgomery county, in the slate formation, some of which have produced a large amount of gold; the gold is mostly crystalline, in flat pieces, often covered with octahedral crystals, and in large nuggets; very little fine-grained gold has been found.

The best known deposit, which has produced large returns, but which is still, so to say, barely touched, is the so-called Christian mine.

The Swift Creek mine, about seven miles distant, produces gold of similar appearance.

West of the Blue Ridge several gravel deposits have been worked, to a greater or lesser extent, in Cherokee and Jackson Counties, also at Howard's Creek, in Watauga, and on the French Broad and New Rivers.

Throughout the whole gold region, every stream, branch and rivulet contains gold; and, as the washing of these is the most convenient way to obtain the precious metal on a small scale, there is hardly one which is not more or less worked, many of them up to their source.

*Platinum.*—Only a few grains have been found in North Carolina, associated with gold in Rutherford and Burke counties; and there is no prospect that it ever will be found in large quantities.

*Silver, Lead, Zinc.*—I shall consider those three metals under one head, as they are always associated.

Silver is a rare metal in North Carolina. With the exception of the silver alloyed with gold, varying from 1 or 2 to about 20 per cent. in the gold from veins and gravel deposits of the granitic and gneissoid rocks, very little silver has been found in the veins of these strata.

The only localities which came under my notice were at the Baker mine, in Caldwell, and at Scott's Hill, in Burke county. There it occurs but rarely, in veins of auriferous quartz. At the latter place it is only observed after burning the ore, and a little fragment which I have seen makes me feel confident that it is present as cerargyrite, or chloride of silver.

Small quantities of argentiferous galenite and pyromorphite are associated with it.

Native silver has been observed with chalcocite or copper glance at Gap Creek mine, in Wilkes county, and at the Asbury vein in Gaston county.

The only real silver mines of North Carolina are ore beds of zinc blende, mixed with galenite, in the argillaceous and talcose slates. The type of these is the old Washington mine, now Silver Hill, in Davidson county, which was discovered in 1838. Near the surface it formed a bed of carbonate of lead, having in many places films and plates of metallic silver disseminated through the mass of the ore. These ores were easily reduced, and produced handsome returns to the owners. This was, however, but of short duration. The undecomposed ores, which were a very fine-grained mixture of brown zinc-blende and argentiferous galenite, were soon reached, and presented great difficulties in the extraction of the precious metals.

When I was at the mine, about twenty-two years ago, an analysis of an average sample of between 2,000 to 3,000 tons of ore gave me about 45 per cent. of zinc, 21 per cent. of lead, about 8 ounces of silver per ton, with minute quantities of copper and gold. If the Philadelphia owners had abided by my advice, viz., to work the ores for zinc, and extract silver, copper, and lead from the residues, they would probably still be in possession of this valuable mine.

The ore bed is large, and in one place has had a thickness of about 60 ft.

Occasionally it contains very rich spots, with native silver in lumps and filiform masses, or disseminated through the ore with argentite or highly argentiferous galenite; and besides these minerals this mine has furnished the most magnificent cabinet specimens of cerussite, pyromorphite, &c.

The mine is now 650 ft. deep, and the ore is greatly mixed with slate. The purer masses are kept separate; the slaty ore is crushed and separated by buddles, &c., and the buddled ore is roasted and shipped to New York for the manufacture of the so-called Bartletts' white lead. The production of this mine is now about 400 to 500 tons per month.

Very similar ore is found about six miles north-east of Silver Hill. The vein has not been developed, and the work done at Silver Valley has not been productive.

The Hoover mine, about six miles from Silver Hill, contains galenite, in a more coarsely crystalline variety, in a calcareous veinstone, and the Boss mine, two miles distant, has furnished handsome cabinet specimens of galenite in quartz.

The McMakin mine, about 1¼ mile south-east from Gold Hill, is a very interesting one; the principal vein is a large vein of zinc-blende in talcose and argillaceous slates; it contains native silver, argentite, argentiferous galenite, and a highly argentiferous tetrahedrite. The latter contains, according to my analysis, 10·53 per cent. of silver, and an average sample of ore of a 5′ vein, at 80 ft. depth, which was sent to me about eleven years ago, yielded 246 ounces of silver per ton, worth about 334 dollars. The mine is not worked, but looks favourable enough to deserve fresh attention.

The Troutman mine, also in the neighbourhood of Gold Hill, and one mile south-east of it, has been opened as a gold mine. It consisted of porous quartz, and yielded near the surface very rich ores, worth 50 dollars per bushel; at the depth of 100 ft., where the sulphides are undecomposed, the ores yielded only 1 dollar, and contained a string of ash grey zinc-blende with pyrite, from 2 to 6 in. in width, which had increased to 18 in. when abandoned at a depth of 160 ft. These ores are well worthy of a fuller investigation, as they may be rich in gold.

I have already mentioned, when speaking of gold, the beds and veins of gold ore in Union and Montgomery counties, as being frequently associated with zinc-blende. The string veins of the Steele Mine principally consist of these and galenite.

At the Long (or Monroe) mine, in Union county, the quartz veins in the slates are richly charged with argentiferous galenite; but the veins have not been sufficiently explored to know whether it will increase in depth.

At the Lemmond (Marion) mine, a very remarkable vein or bed has been worked; it is irregular in size, sometimes widening out from a few inches to 6 ft. It consists of quartz, richly charged with brown zinc-blende and galenite, with small quantities of arsenopyrite, chalcopyrite, often intermixed with grains of electrum, a highly argentiferous variety of gold. Both the galenite and the zinc-blende are very rich. I have examined a *pure* specimen of galenite which did not show any admixture of *free* gold to the eye, but which yielded at the rate of nearly 30 ounces of gold and 86½ ounces of silver to the ton; and pure brown zinc-blende gave me about 32 ounces of silver and gold, nearly half of which was gold. This vein appears to have a considerable longitudinal extension, and passes into the Steward mine property, formerly owned in this city.

At the latter mine, and at various other localities in this region, similar ores have been found, but the war has stopped all operations, and it will require capital and skill to develope this highly important mining district.

Galenite and zinc blende occur at several other mines, associated with gold ores, as at the King's Mountain, the Cansler and Shuford, and the Long Creek mines in Gaston county, &c. At Cedar Cove, McDowell county, in the limestones of the so-called taconic slates, at the Dobson mine, there is found an accumulation of yellow and yellowish-brown zinc-blende mixed with lime. I have not, however, seen anything from there which looks encouraging.

Galenite and zinc-blende are associated with the gold ores at Murphy, Cherokee county. Highly argentiferous galenite occurs at several localities on Beech Mountain, Watauga; argentiferous and auriferous galenite have been discovered at Flint Knob in Wilkes county, and I have seen specimens of it from Marshall, Madison county, Clayton, Johnson county, and Elkin Creek, Surry county, and also in several of the copper mines throughout the State, but I have no knowledge of any deposit of sufficient magnitude to be worked advantageously.

*Tin.*—No tin ore has been found in North Carolina as yet. Traces of this metal have been found in the tungstates of Cabarrus county, and in a micaceous slate in Gaston county, associated with garnet and columnar topaz (pycnite).

*Copper.*—Copper ores have been found in many localities throughout the State, in the veins of the old gneissoid rocks, as well as in the more recent slates, and even in the triassic formation.

The principal ore is chalcopyrite or copper pyrites; and there is every reason to believe that many of the mines require only a fuller development to enable them to furnish large quantities of valuable ores.

I have already mentioned that many of the gold veins are associated with pyritic ores, and in fact almost all the North Carolina copper mines in the central counties have first been worked for gold, and there are hardly any mines in Guilford, Cabarrus, and Mecklenburg counties occurring in the gneissoid and syenitic rocks, which do not show strong indications of copper ores.

When mining operations receive a new impetus, it is to be hoped that this very important fact will be borne in mind, and that no mine should be started without sufficient means to develope it at once to such a depth that a workable body of copper ores may be reached.

The general character of these mines is that about at water-level the so-called brown gold ores are replaced by quartz richly charged with iron pyrites more or less mixed with copper pyrites, the latter increasing as the mine deepens, and in many places becoming the only or the predominating ore, and forming a regular copper vein.

The ores either became poor in gold or the latter could not be extracted by the ordinary process, then chiefly in use in North Carolina—Chilean mills and arastra—therefore many valuable mines were abandoned, mostly before a larger and paying quantity of copper ores had been reached.

In this formation there is not at present a single copper mine in operation, although many look favourable for further development.

The principal mines which promised to change into copper mines are:—In Guilford county, the Fisher Hill, the North Carolina, the McCulloh, Lindsay, Gardner Hill, Twin mines, &c.; in Cabarrus county, the Ludowick, Boger, Hill, Phœnix, Orchard, Vanderburg, Pioneer Mills, &c.; and in Mecklenburg the McGinn, Hopewell, Rudesill, Cathay mines, &c.

The cupreous minerals observed in these mines are near the surface, small quantities of native copper and cuprite, the latter sometimes in beautiful needles, the so-called chalcotrichite, malachite, rarely azurite, chrysocolla and pseudo-malachite, and in some of the mines chalcocite and barnhardtite; all resulting from the decomposition of chalcopyrite or copper pyrites, which forms the principal ore. Siderite or carbonate of iron often forms an important gangue rock.

A very important copper region extends through many of the western counties of North Carolina, which is best developed in Jackson, Watauga, Ashe, Wilkes and Alleghany counties. The ores occur in hornblendic slates and gneissoid rocks.

In Jackson county, at the Savannah, the Cullowhee, the Wolf Creek mines and others, large quantities of chalcopyrite or yellow copper pyrites have been obtained; at Elk Knob, in Ashe county, the ore consists of chalcopyrite with pyrrhotite, in a gangue rock consisting of a dark-coloured micaceous quartzite. The Ore Knob in the same county has furnished chalcocite or copper glauce.

At Gap Creek mine, in Wilkes county, the ore consists of quartz with bornite or variegated copper ore and chalcopyrite. The ore sometimes contains silver and gold.

The Peach Bottom mine in Alleghany county has been worked to a depth of 150 ft., and has produced a considerable quantity of ore; galenite occurs in a portion of the vein.

This whole mining region is well worthy the attention of capitalists, and when better facilities for transportation are offered, I have no doubt that it will be more fully and profitably developed.

The only two copper mines in North Carolina which are worked at present, to a limited extent, are in the so-called taconic slates.

The Clegg mine in Chatham county is a large quartz vein in argillaceous slates. It is developed to a depth of 200 ft., and has furnished large bunches of valuable ore. The ore is chiefly chalcopyrite, but other cuprose minerals have been found, among which azurite in small but beautiful crystals. The mine is in excellent order, and the machinery is of the best quality, and very efficient. I understand that arrangements have been made to smelt the ores on the spot. Copper ores under similar circumstances are found at other places in Chatham, also in Person county.

The other mine is the so-called Emmons or Davidson copper mine, about six miles from Lexington. It has also been opened as a gold mine, but the ore was poor, containing not over thirty-seven cents per bushel, with a large admixture of iron and copper pyrites, occurring in a dark bluish-green chloritic slate. It has been abandoned therefore as a gold mine and is worked only for copper. I learned a few days ago that works for the extraction of the ore by the humid way are in contemplation.

Almost identical in appearance, but richer in gold, is the so-called Barnhardt vein of Gold Hill. In the neighbourhood of Gold Hill are several localities which have yielded rich copper ores; especially the Union copper mine in Cabarrus, about one mile from Gold Hill; it was worked more than any other in the neighbourhood, and has furnished crystallized copper and cuprite, and a mixture of chalcocite and chalcopyrite and other ores.

Other mines in the neighbourhood of Gold Hill, also several in Randolph and Davidson counties, contain more or less copper; for instance, the Conrad Hill shows strong indications of copper.

*Arsenic, Antimony and Bismuth.*—Only a few ores of arsenic and antimony have been noticed in North Carolina. Amongst these is very rare native antimony, of which a small piece was submitted to my examination by Dr. Hunter, of Cottage Home, Lincoln county. It has been found in a small vein in Burke county. An examination proved it to be quite pure.

Both arsenic and antimony are found in combination with other metals: arsenic at a few localities in Union and Gaston counties, in small quantities, as arsenopyrite or mispickel, associated with gold ores; and both arsenic and antimony in the highly argentiferous tetrahedrite of the McMakin, and the tetrahedrite of the Ludowick mines in Cabarrus county.

Bismuth has been observed as bismuthinite in minute particles associated with the gold and copper ores of the Barnhardt vein at Gold Hill, and by Dr. Asbury as bismuthite with gold ores at the Asbury mine in Gaston county; also as bismite, or teroxide of bismuth, in the same mine, and in combination with copper, lead, and sulphur, at Colonel White's mine in Cabarrus county, probably as aikinite. The most interesting ores are the telluride of bismuth (tetradymite) and the tellurate of bismuth (montanite) both found associated with gold ores in numerous localities—in Davidson, Cabarrus, Gaston, McDowell and Burke counties. The bismuthic gold mentioned by Shephard as coming from Rutherford, is probably an artificial product resulting from the simultaneous amalgamation of gold and tetradymite.

*Cobalt and Nickel.*—Small quantities of these two metals have been observed in the manganese gossans of several mines in Gaston county, but thus far no regular workable deposit has been found.

*Manganese.*—No regular manganese deposits are as yet known in North Carolina; small quantities of pyrolusite, psilomelane and wad have been observed associated with iron, gold and silver ores, in several localities in the States. Many of the iron ores contain a small percentage of manganese.

The *manganese garnet* may become of considerable importance in the iron industry; it occurs in several large veins or beds. At Buckhorn it is associated with the magnetic iron, and serves as a valuable flux; it is also found near Danbury in Stokes county, in Rowan and Rutherford counties.

*Chrome.*—Minute quantities are found in the magnetic iron belt passing through Guilford and Rockingham counties. Deposits of considerable magnitude exist in the chrysolite beds of Jackson, Mitchell, Yancey, and Watauga counties.

None of them are worked at present.

*Iron.*—Although the mineral wealth of North Carolina is affirmed beyond a doubt by its numerous mines and deposits of gold, copper, silver, and other metals, still its greatest resources consist in its vast iron ore beds, distributed throughout the entire State; and when these are properly developed, their importance will by far exceed any other mining interest.

It may be safely predicted, that, at an early day, North Carolina will stand foremost as an *iron*-producing State; not only because the various varieties of iron ore exist in inexhaustible quantities, but also because they are of very superior quality, and offer all those requisites to making the better and more desirable grades of *iron* and *steel.*

The principal ores are—the pure magnetic iron, the titaniferous and chromiferous magnetic iron, menaccanite or titaniferous iron, hematite or specular iron, limonite or brown hematite, and carbonate of iron. These ores, especially the magnetites and hematites, being in reality only a more ferriferous portion of the stratification, form strings of large lenticular beds in the rocks, here and there interrrupted, but extending for many miles, and in some instances stretching across the entire State.

The outcrops of those ore beds being so very numerous, I cannot do more than indicate the various ranges and the localities where the ores are best developed.

But as there are also many places from which I have seen very fine ores, which require fuller investigation as to quantities, I will mention the locality, in the hope that this may lead to important discoveries. For the sake of convenience, I will commence with the most eastern locality, and take up the different nearly parallel beds in succession, up to the Tennessee line.

One mile east of Gaston, near the Roanoke River, there occurs a granular variety of hematite, more or less mixed with red and yellow ochre. The ore is apparently of very fine quality, but nothing is known as to whether it exists in quantities or not; if found in abundance, its location would make it valuable.

A large deposit of brown hematite occurs in the slate formation connected with quartzites, four miles west of Smithfield, Johnston county, and a bluff of limonite is exposed at Whitacker's, seven or eight miles south-west of Raleigh, in argillaceous and chloritic slates.

The various iron ore deposits of Chatham and Moore counties are of much greater importance.

At Buckhorn, on the Cape Fear River, a large bed of granular magnetite has been developed, from which, if I am correctly informed, about 6000 tons of very superior iron have been produced. The bed is between 20 and 30 feet thick, and lies almost horizontally between mica schist. This magnetite is associated and largely intermixed with manganesian garnet, which serves as a flux, and renders it very easy to smelt. The iron was used during the war for car-wheels, and was of such excellent quality that one of the wheels, coming accidentally into the possession of a firm in Wilmington, Del., induced them to purchase the property, with a view to establish similar works in North Carolina. The beds dip slightly to the south-east, and appear to extend in this direction, and also to the south side of Cape Fear River.

A number of beds of hematite or specular iron make their appearance in Chatham county, in the argillaceo-talcose slates; the ores are the compact and granular hematite, of reddish, greyish, and iron-black colour, sometimes laminated, foliated, and micaceous.

In Moore county, 12 miles east of Carthage, near Governor's Creek, there occurs a pure massive kidney-shaped hematite, without admixture, probably the south-west continuation of one of the Chatham ore beds.

On Ore Hill, in Chatham county, not only red hematites are found, but also large beds of brown hematite or limonite. This hill is between 200 and 300 feet high, and perhaps two or more large veins, of about 10 to 15 feet in thickness, intersect the hill in an east and west direction.

The limonites are of fine quality, but their appearance and geological position would indicate that they are merely "gossans," or decomposed pyritous ores, and the probability is, that at a greater depth the unaltered sulphides will be found. Since my return from North Carolina, the Ore Hill has been sold for 150,000 dollars, and there is a prospect that the old furnace on the place will soon be rebuilt and be put into blast.

The Evans ore bed is from six to eight feet wide, and has been traced for nearly one mile; it is about four or five miles from the Gulf, and consists of red hematite, of fine quality. Kelly's ore bed and several others show the same character.

The ores which I have seen are excellent, but none of them are worked.

Beds of granular magnetic iron, of fine quality, have also been found not far distant, but none of them are developed. One, for instance, is about two to three miles north of the Evans ore bed.

I cannot leave Chatham county without mentioning the peculiar ores which, many years ago, have been much speculated upon as being of immense value,—I mean the so-called *Black Band* ores interstratified with the coal. There are three seams of this black band between the coal beds. One of these seams is six feet in thickness, and consists of argillaceous carbonate of iron in balls and layers.

Unfortunately, only a very small quantity of this ball ore could be selected which would be pure enough for the manufacture of iron. The *great mass* contains such an abundance of bones and teeth of saurians and fishes, that the amount of phosphoric acid in the same renders it absolutely worthless as an iron ore; the quantity of phosphoric acid is so great that it has been proposed to apply it to the soil as a manure.

A band of red hematite, probably the continuation of one of the Chatham county beds, passes through Orange county. It is quite prominent on a hill about one and a-half mile north-west of Chapel Hill. The surface is covered with ore, some of it almost pure sesquioxide of iron. Like Pilot Knob, in Missouri, it forms a series of quartzose bands, frequently with bands of pure ore alternating with quartz more or less mixed with ore.

North-east from it, in the same county, at Red Mountain, extensive beds of this ore have been discovered.

In Montgomery, Randolph and Alamance counties, several iron ore beds have been found, which at a future day may become of importance.

Six or seven miles south-west of Troy, a band of hematite lies between bands of auriferous slates, bordered on one side by quartzite, on the other by slaty pyrophilite. It forms a mass of about 50′ wide, which has been traced for a quarter of a mile. The bed is traversed by massive hornblende.

About four miles north of Troy a series of magnetic iron ore beds occur in the neighbourhood of Carter's gold mines. The ore is frequently crystallized, friable, and is intermixed with talc and quartz. The continuations of some of these ore beds pass through Randolph and Alamance counties, where they yield ores of most excellent quality; as, for instance, three or four miles south-west of Franklinville, where an abundance of fine magnetite is found on the surface in the immediate proximity of a vein, and at La Grange; at the latter place there also exist large deposits of bog iron ore.

Some of the most important developments have been made within the last two years by the North Carolina Centre Iron and Manufacturing Company of this city, not only in the great titan-

iferous iron belt which passes principally through Guilford and Rockingham counties, and extends through the edges of Forsythe and Davidson counties, but also in numerous outcrops, forming parallel ranges with this formation.

I have already mentioned the accumulation of iron ore in the gneissoid rocks of the Greensboro' Belt.

The ore forms one or more strata between the rocks, and their extent has been proved for about thirty miles. Near the north-eastern extension the ore beds present a remarkable character, as proved by Prof. J. P. Lesley. He has shown the beds to be outcrops of the same synclinal basin, the so-called Tuscarora range being the south-east outcrop, with a north-west dip, while the so-called Shaw range is the north-west outcrop, with a south-east dip. The ore is a granular magnetite, more or less mixed with a micaceous mineral, also with hematite or menaccanite, and in some places it is associated with granular corundum or emery.

The average yield of the ore is 55 per cent. of iron; it contains, as I have already mentioned, small quantities of chrome, cobalt and manganese, and on an average about 13 per cent. of titanic acid, equal to 8 per cent. of titanium.

This titanic acid is not chemically combined with all the ore; in some of the varieties I have succeeded in separating, by the magnet, ore which was almost free from it, leaving the not magnetic menaccanite behind.

During the war, it was worked in bloomeries on a small scale, about two miles from Friendship, Guilford county, on a place which is now called Tuscarora, and has produced a quality of iron which was very remarkable for its toughness, its great strength, and adaptation for the manufacture of steel.

Almost in range with these ore beds, magnetites as well as titaniferous iron ores have been found at several places in Mecklenburg county: the first, eight or nine miles from Charlotte, of Steel Creek Church; also, about seven miles from the same town, on the York road; and the titaniferous ore near the Harris mine, twelve miles south-east of Charlotte. It cannot at present be ascertained whether these ores are connected with those of Guilford county.

Before I proceed with the consideration of the numerous iron ore beds of the slates of the King's Mountain group, I will mention that north-west of the titaniferous iron ore ranges of Rockingham, Guilford, &c. counties, at least three ranges have lately been found between it and the Dan River, called the Johnny Watson, Love and McQuillan ranges. No developments have been made as yet, but the analyses of some of the ores show them to be free from titanic acid, and yielding about 50 per cent. of iron.

A very extensive and important belt of iron ores, which has furnished the greater portion of the iron used in the State, occurs in the slates of the King's Mountain group. It consists of a series of parallel magnetite ore beds extending, with frequent interruptions, from the neighbourhood of Danbury in Stokes county, across the entire State into South Carolina.

The character of this series of magnetite beds is so uniform that it would be tedious to enumerate all the important beds; I will therefore point out only a few of the most characteristic ones.

The ores are granular magnetites *without titanic acid*, at times quite pure, but generally in part altered into hematite, and more or less intermixed with fine grained actinolite, tremolite, talc or chlorite and frequently associated with small quantities of epidote. The average of the ore is above 60 per cent.

A very fine bed of this granular magnetite associated with actinolite is the Rogers ore bank, near Danbury in Stokes county, which has been worked for a long time, and the ore smelted at the furnace on the Dan river.

There are several parallel ore beds; the upper is of the finest quality and most valuable. It is between seven and twenty feet in width, yielding on an average about 60 per cent. of iron. The ore is almost free from phosphorus and sulphur. Some of the smaller beds at their outcrop are rather sulphurous. Similar very fine beds occur in Surry county; the ores are schistose granular magnetites, with talcose, micaceous and quartzose admixtures.

At Tom's Creek this ore has been worked since 1795, and bloomeries are now in operation. Other ore beds, which also have been extensively worked, are the Williams Ore Bed and the Hyatt's Mine.

The southern continuation of the ore beds of Stokes and Surry are developed again in Forsythe and Yadkin counties. The character of the granular magnetites remains the same, and is an association of talc or actinolite. They have been extensively worked at Hobson's in Yadkin county, near the east bend of the Yadkin River, and other places.

Probably the beds in Davie county, on the South Yadkin River, are the same, and pass through Iredell county near Statesville into Catawba and Lincoln counties, where they have again been extensively worked for a long time in blast furnaces, as well as in bloomeries, producing iron of great strength and toughness.

In Gaston county the same beds of granular magnetite, to a great extent altered into hematite, with a fine grained actinolite slate, have been worked on the High Shoal property on the Little Catawba River, at Ellison's and Carson's Ore Banks.

Not only magnetites furnish the material for the production of iron, but also very fine limonites, fibrous, cavernous and partly resulting from the alteration of carbonate of iron, often yet showing its crystalline structure. They occur in large veins or beds in the slates; as they result mostly from the oxidation of pyritous ores, it may be expected that at a greater depth this will replace them entirely. The Orman and Mine Mountain and Ferguson Ore Banks, all on the High Shoal property, have been extensively worked. It is to be regretted that litigations have thus far prevented Admiral Wilkes from commencing operations at this highly valuable property, with its magnificent water power and other facilities for conducting a large manufacturing business. Near the top of Crowder's Mountain a vein of specular iron has been found. In the vicinity of King's Mountain the magnetic ores have been worked since the latter part of the eighteenth century. One of the ore beds is about forty feet thick. Besides the magnetites there are also limonites of good quality. A very striking feature of this very important and extensive belt of magnetites is its proximity to a parallel band of limestone, which accompanies the iron ore at almost every locality from Danbury down to King's Mountain.

Entering again the gneissoid rocks, we meet near Newton in Catawba county a very valuable bed of granular magnetic iron in syenite, resembling the ore from Cranberry in Mitchell county.

Magnetites as well as hematites are found in Wilkes and Caldwell counties, some of which were formerly manufactured into iron. One very promising outcrop of large beds of fine granular titaniferous magnetite, for instance, has been observed near the Yadkin River, one mile west of Patterson, and another two miles north of Hickory, both in Caldwell county. At the latter place there also occurs red hematites and limonites in large deposits and of excellent quality. It is probable that further developments may prove the existence of a more extensive range, since similar granular magnetites have been found near Morgantown, almost in a line with the strike with the more northern beds.

Another bed accompanies the limestone of McDowell county on both sides of the North Fork of the Catawba River; the ores are limonite, sometimes also hematite mixed with magnetite. These limonite beds continue to the west of the Blue Ridge, where we find them again overlying the limestone in Henderson and Transylvania counties.

Several beds of limonite, and occasionally hematite, of good quality, exist in several localities of Buncombe county, so at Ore Mountain, two miles south west of Swannanoa Gap, and also four to five miles west of Ashville.

The magnetites and hematites west of the Blue Ridge deserve the highest attention, as they are not only of very superior quality, but also found in inexhaustible quantities. The most northern bed of magnetites is found in Ashe county at the North Fork of New River, near Hilton Creek. The ore is granular and talcose, in its general character almost identical with the ores of the King's Mountain range, being granular magnetites of somewhat slaty structure from the intermixture of small quantities of talc. The ores have been worked in bloomeries and have yielded a good quality of iron.

A very superior ore occurs at Cook's Gap in Watauga county. It consists of an almost pure stratified red hematite with octahedral crystals of magnetite disseminated through the mass. It is associated with limonite. It is an ore worthy of fuller investigation.

A number of iron ore beds are found in Mitchell county; the most valuable deposits are about one and a half miles south of Cranberry, near the Tennessee line. The ore beds have not been sufficiently explored to show their geological character and size, but they appear to be inclosed between hornblende slates and a peculiar micaceous slate.

The size of the ore beds must be enormous; judging from the outcrops it may have a width of 300 to 400 yards, and extends for more than half a mile; the whole side of the hill is covered with large blocks of the finest quality of magnetite, which evidently exists there in inexhaustible quantities.

The magnetite is often quite pure and polaric, coarse-grained, sometimes crystallized in octahedra, and associated with pyroxene and epidote. The pyroxene weathers into a brown ferruginous clay, in which are inclosed grains of magnetite. As these ores are soft and require little labour, they are the only ones worked

and converted into blooms at the works about two miles distant. The whole production is not over one ton of blooms a day. The finest quality is not touched. The analysis of a specimen representing about the average character of the ore, showed it to be entirely free from sulphur and phosphorus, and containing 65 per cent. of iron.

There are several promising outcrops of magnetic ore beds in Mitchell county, but most of the other ores are menaccanite, which occurs at the following localities:—at Crab Orchard, Cane Creek, and Flat Rock.

In Madison county, on the east fork of the Big Laurel, a large outcrop of slaty fine-grained granular magnetites, of apparently very good quality, occurs, also a highly titaniferous menaccanite, containing nearly 38 per cent. of titanic acid. A bed of specular iron exists at Jewel Hill.

Other beds of magnetic ores in the same county occur in hornblende slates near Fines Creek in Haywood, and in garnetiferous mica schist at several points in Macon county.

I have yet to mention the immense beds of limonite or brown hematite, which occur in several localities in Cherokee county, associated with the limestone or marble and talc, one of which is worked, about one mile from Murphy.

The ore is of very fine quality, compact, also porous and fibrous, in some places ochreous; the quantity is inexhaustible, and beyond doubt the region where these deposits exists will sooner or later become a large iron manufacturing district.

*Coal.*—The great abundance of iron ores in North Carolina requires for their reduction a large amount of fuel, and the question of its supply has for a time given a great deal of anxiety to those who are most largely interested in the manufacture of iron, as under the present system of forest destruction, instead of cultivation, the manufacture of charcoal iron must eventually be abandoned, although this may not take place for hundreds of years yet to come. It is therefore of the greatest importance that North Carolina contains several kinds of coal, some of which are of excellent quality, and in the immediate neighbourhood or within a short distance only of the most valuable iron ore deposits.

I have already stated that the North Carolina coal does not belong to the so-called carboniferous period, but to the triassic; it is of the same age as the coal near Richmond, Va.

In Chatham and Moore counties is the south-eastern extension, generally called the Deep River Coal Field; in Rockingham and Stokes counties the north-western of the same beds, or the Dan River Coal Field. The centre is washed away.

From the investigations of Prof. Emmons and Admiral Wilkes, we learn that the Deep River coal is of the best quality, well adapted for the manufacture of iron and gas, and can be obtained in inexhaustible quantities.

The area underlaid by coal is over forty square miles, containing over 6,000,000 tons of coal to each square mile. The coal measures consist of strata of slates, calcareous shales, alternating with beds of argillaceous carbonate of iron and seams of coal, all inclosed between two beds of red sandstone.

Five seams of coal have been observed; the upper consists of a bed of six and a-half feet in thickness, separated by a seam of black band. Near the outcrop it is somewhat contaminated with sulphur, which diminishes, however, as the depth increases. There are several varieties of coal, the highly bituminous and semi-bituminous; near a trapdyke it has lost almost the whole of its volatile matter and has become an anthracite. According to an analysis of coal from the deep pit at Egypt, by Dr. Jackson, it contains:

| | |
|---|---|
| Fixed carbon | = 63·6 |
| Vol. matter | = 34·8 |
| Ash | = 1·0 |

An analysis of Egypt coal, which I have lately made, gave:

| | |
|---|---|
| Moisture | = 0·84 |
| Vol. matter | = 25·75 |
| Fixed carbon | = 63·27 |
| Ash | = 10·14 |
| | 100·00 |

It contained 1·35 per cent. of sulphur.

An analysis of coal from the Gulf gave me:

| | |
|---|---|
| Moisture | = 1·16 |
| Vol. matter | = 21·90 |
| Fixed carbon | = 70·48 |
| Ash | = 6·46 |
| | 100·00 |

Sulphur only 1·02 per cent.

All these analyses show the great value of the Deep River coal.

The Dan River coal field embraces an area of over thirty square miles; it has hardly been developed. Small quantities have been mined near Madison, Rockingham county, which were used by the blacksmith in the neighbourhood; and the North Carolina Centre Iron and Manufacturing Co., of this city, has made a few trial pits which have proved the existence of five beds of coal, although it is probable that there are others besides.

The coals which I have examined from two of the seams near the outcrop gave respectively, 11·44—13·56 per cent. of ash, 75·96 and 76·56 per cent. of fixed carbon and about 12 per cent. of volatile matter. These results are very encouraging. The Dan River coal field being the north-west continuation of the Deep River, has probably the same seams, and, where the coal is undisturbed, the same quality of coal. These coal fields are not only of general value, but, when it is remembered that they lie in close proximity to some of the largest and best iron beds in the State, their importance can then be fully appreciated.

*Diamond and Graphite.*—North Carolina possesses carbon, not only in the form of several varieties of coal, but also in its two other modifications, as diamond and graphite.

Both occur in the old gneissoid rocks, the graphite in beds inter-stratified with the mica schist or gneiss; the diamond in the *débris* of such rocks, associated with gold, zircon, garnet, monazite and other minerals.

It is very remarkable that these two minerals are found in strata of the same age; and this fact reminds me of an analogous one, which may throw some light on their origin, viz., in producing the adamantine boron we always obtain the graphitic form at the same time.

Diamond has not been observed in North Carolina in any more recent strata, and in the itacolumite regions *no* diamonds have ever been found, as in Brazil; from which it appears that the itacolumite of Brazil is either simply a quartzose mica slate of similar age with the North Carolina gneissoid rocks, or that, if it is cotemporary with the North Carolina itacolumite, the diamonds were not *produced* in the same but came from older rocks, and were re-deposited with the sands resulting from their reduction to powder, and are now found imbedded in the same, their hardness having prevented their destruction. Seven or eight diamonds have thus far been found. They occur distributed over a wide area of surface in the counties of Burke, Rutherford, Lincoln, Mecklenburg and Franklin, and I have no doubt, if a regular search were made for them, they would be found more frequently. Some of the stones were fine crystals of first water; their weight was from one-half carat to about two carats.

*Graphite*, so much in demand now for the manufacture of crucibles for melting steel and other metals, for lead pencils, as an anti-friction agent, for stove blacking, paint, &c., is found in numerous localities in the State.

The largest beds known since nearly half a century occur a few miles west of Raleigh in Wake county. There appear to be two belts about half a mile apart; the beds contain several seams of greater purity from six to eighteen inches in width. The beds are known to extend for a distance of eighteen or twenty miles.

It has been explored seven miles north-west of Raleigh, and a shaft has been sunk to a depth of one hundred feet. It is mostly mixed with fine grit and is rather slaty, and would require mechanical means for the separation of the impurities. Other beds of graphite, but not so extensive, are found in Lincoln, Caldwell, near Hickory, and in Burke counties near Morgantown. None of them are developed. The best quality which I have seen came from Alexander county, three miles from Taylor's, and from Cane Creek in Person county.

*Sulphur* is not found in North Carolina, except occasionally in small crystals, in cavities of quartz, resulting from the decomposition of pyrite. A large supply of sulphur ores will be furnished when the mines of the State are worked to a greater depth. One large vein of pure iron pyrites occurs in Gaston county. Most of the other veins will furnish in addition gold and copper.

*Corundum.*—Corundum, which, on account of its hardness, is so much sought for as a cutting and polishing material for hard substances, has been found, in a state of great purity and abundance, at several places in the neighbourhood of Franklin, in Macon county, in connection with granites and chrysolite rocks.

It is mostly greyish or brownish, but sometimes it assumes a beautiful sapphire blue and ruby colour. It is to be regretted that the blue has not yet been found in pieces large enough to be cut for gems, and that the ruby has not the requisite transparency. A large boulder of dark blue corundum was found,

many years ago, near the French Broad River, in Madison county. It has lately been observed on the Burnsville Road, nineteen miles from Ashville. In small quantities it is found at Crowder's and Clubb Mountains, Gaston county.

The granular corundum or emery is associated with the magnetites of the great titaniferous iron range in Guilford county.

*Rutile.*—Titanic acid, in the form of rutile, used in the arts to give a peculiar colour to artificial teeth, is found in considerable quantity at Crowder's and Clubb Mountains, in Gaston county; also at several localities in Mecklenburg and Mitchell counties.

*Mica, Feldspar, Kaoline, Pyrophyllite.*—Hundreds of years ago, long before the Indians occupied the territory of North Carolina, many excavations were made in the numerous large coarse-grained granite beds of Mitchell, Yancey, Cleveland and other counties. In the year 1867 a number of these old mines have been taken up again, and now mining, on a somewhat extensive scale, is going on, and a great portion of the mica used in the arts for stoves, lamp-shades, window-panes, &c., comes from Mitchell and Yancey counties, North Carolina. The mica has mostly a slightly brownish colour; it occurs, irregularly distributed, through the granite, in rounded pieces, some of them weighing several hundred pounds. It is then split and cut into marketable shapes, which, according to size, will sell from 1 dollar to 10 dollars per pound.

The same localities furnish a very fine quality of orthoclase or potash feldspar, used for glazing porcelain and for artificial teeth.

At some of the mines in Mitchell county the orthoclase is almost completely decomposed, and leaves frequently a snow-white kaoline or porcelain clay. It is found at several other localities, as in Lincoln, Burke and Macon counties.

In the region of the Deep River, in Chatham and Moore counties, very extensive beds of pyrophyllite slate have been worked for a long time.

It is sometimes called agalmatolite, from the fact that from a dense variety of the same rock the Chinese cut and carve their little images, idols and toys. The North Carolina mineral, being entirely free from grit, is largely used as an antifriction material, also for the lining of furnaces, slate-pencils, in the manufacture of wall-paper, as a cosmetic, and for other purposes. Other, though less extensive, beds have been found in Montgomery and Gaston counties.

*Serpentine, Talc.*—Only one locality has come to my notice from which a serpentine could be obtained fit for ornamental purposes. It has a dark greenish-black colour, contains very small seams of a greenish chrysolite, with silky lustre, and acquires a good polish. Found in large quantities 1¼ mile below Patterson, in Caldwell county.

The serpentine found in the chrysolite beds west of the Blue Ridge are of no value.

The most beautiful white, or greenish-white massive, or finely crystallized talc is found, in inexhaustible beds, in many places in Cherokee county.

It is used for similar purposes as the slaty pyrophyllite of Chatham and Moore counties. Massive and schistose talc, or soapstone, suitable for fire-places, mantel-pieces, stove-linings, &c., is found in many localities in the State.

*Barytes.*—This material, when quite white much used as a paint, and more generally for the adulteration of *white lead*, is found in abundance and excellent quality at several localities. A coarsely granular variety, white, like marble, is found in Union county; another similar one, massive and granular, in a vein from 7 to 8 ft. in thickness, in Gaston county, at Crowder's Mountain; and a greyish-white laminated variety, at the Latta mine, near Hillsboro', in Orange county. West of the Blue Ridge it is found, in white granular masses, at Chandler's, nine miles below Marshall, in Madison county.

*Alum and Copperas.*—Many of the gneissoid slates of Cleveland, Rutherford and other counties contain large quantities of pyrites finely disseminated through them, which, by oxidation, or weathering, produces copperas and alum, both of which were therefrom manufactured on a large scale during the war.

*Marble.*—Only in one or two localities, in the limestones of Stokes and Catawba counties, a fine-grained variety is found, which would be useful for ornamental purposes if the quantities were not too limited. West of the Blue Ridge, however, in Cherokee and Macon counties, it is found in large beds, of the finest qualities. There is not only the fine-grained white, resembling that of Carrara, but also the greyish-veined marble, like the Italian, and a most beautiful variety of a fine pink hue.

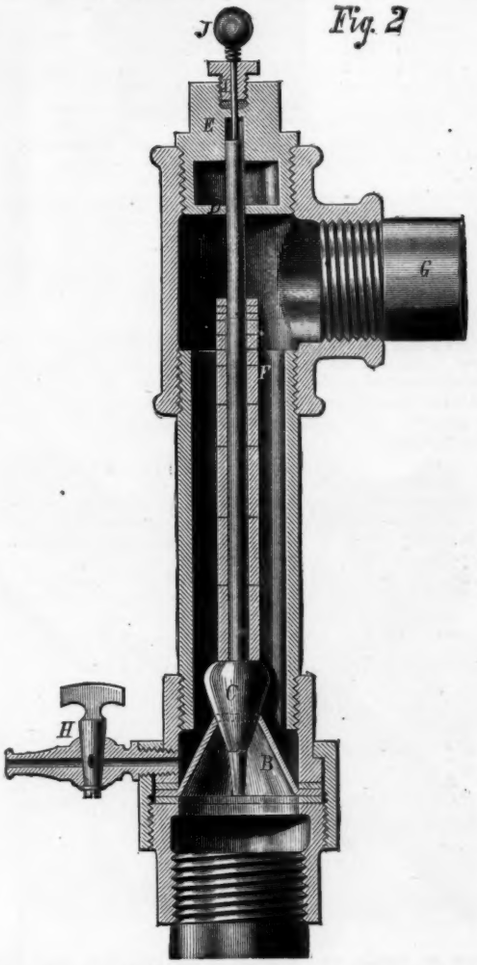
The limits of this paper are already far beyond my original expectations; and still I might add many more details which would be of interest. In as concise a form as possible, I have indicated and described the principal valuable minerals in the State, and the localities where they occur. I have dwelt rather more fully upon gold, copper, iron and coal, because of their greater importance, especially the two latter, which I believe will prove a source of immense wealth to the State.

My various visits to North Carolina, and more particularly the opportunities afforded me for observations during my trip there last summer, have enabled me to collect many facts and data relative to the various mines and mining districts, which doubtless would be of interest, but which want of space compels me to omit for the present. I hope, however, that at some future day it will again be my privilege to present the Franklin Institute with further observations on this interesting subject.

## CASEMENT'S PRESSURE REGULATOR FOR FLUIDS.

IN describing the invention of which our illustrations depict the construction and principal applications, we deem it hardly necessary to prefix any extended prefatory remarks regarding the obvious utility of the type of apparatus to which it belongs. The advantages of a device by which a maximum and normal pressure may be reduced for ordinary continuous

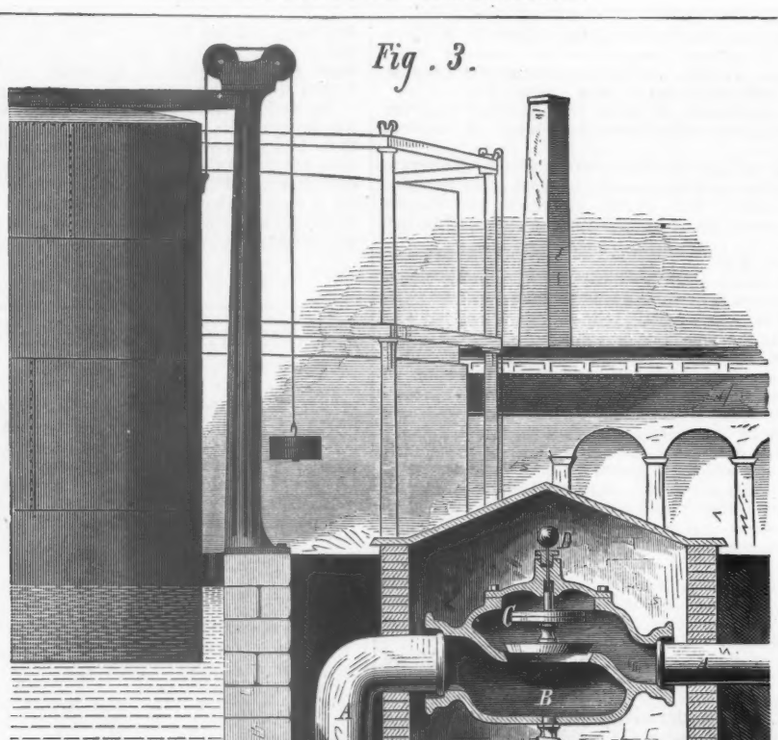
Fig. 2




employment to any required low degree, while the full force is susceptible of instant utilization at any moment: or by which, from a single powerful source of supply, several deliveries may be effected, all varying in intensity: will, we think, be clearly apparent.

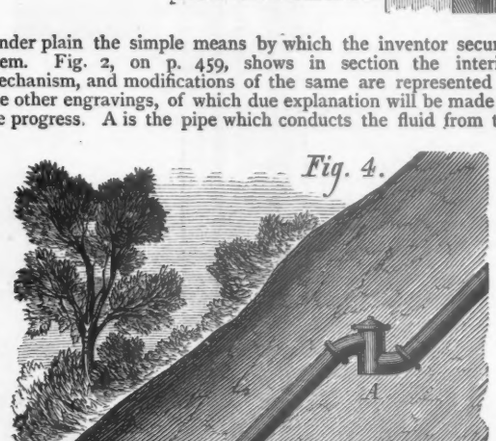
The points briefly enumerated above constitute the objects of the present device, and a reference to our illustrations will

Fig. 3.




render plain the simple means by which the inventor secures them. Fig. 2, on p. 459, shows in section the interior mechanism, and modifications of the same are represented in the other engravings, of which due explanation will be made as we progress. A is the pipe which conducts the fluid from the

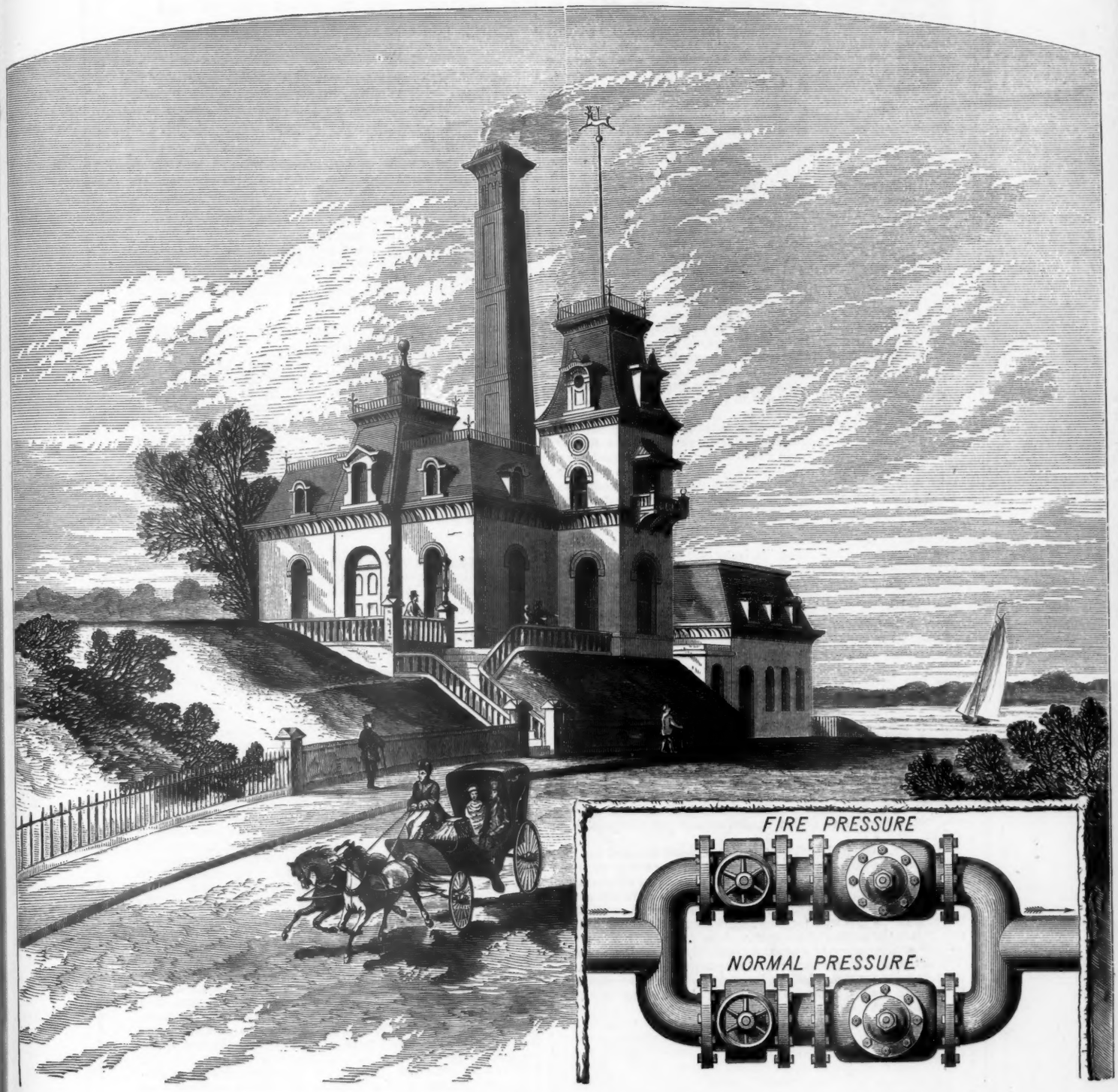
Fig. 4.




source of supply, and represents the apparatus used by the inventor in conducting gas from a natural gas-well to his dwelling at Painesville, Ohio, for heating and illuminating purposes. Just above the orifice of pipe A, is coupled a short section of tube, forming a chamber; and secured between the couplings by a flange and packing rings, is a truncated conical diaphragm B. The latter it is proposed to make of hardened steel, and also as thin as possible, while securing the requisite strength, so that its upper aperture, which forms a seat for the valve C, will be reduced as much as practicable to lessen the area subject to friction, and thus prevent any liability of the valve to stick. Valve C has a long stem which passes up through a guide D. The upper portion of the chamber is closed by a screw plug E, which can be readily removed to admit of access to the interior, and also for the purpose of placing in position the rings F, of heavy metal, which serve to weight the valve.

We will suppose that the gas escapes from its source under the high pressure of 20 lbs. to the square inch, and that it is desired to distribute the same at a constant pressure of but one-third of a pound. In such case the weights on valve C would be adjudged to aggregate 19⅔ lbs. It is evident that, with this force acting in one way opposed to the greater one coming from the other direction, the amount of gas corresponding to the difference between the relative pressures would be that allowed to pass the valve; for should the pressure above the valve equal that below it, clearly gravity would bring the valve to its seat, closing the orifice and preventing further escape, until the pressure above once more became less than the force acting from below. Hence by adjusting the weights any degree of pressure in the distributing pipe may be maintained. The valve is, of course, automatic, and as it is held suspended by the upward current, adjusts itself to the quantity of gas demanded, so that, as a moment's consideration will show, the sudden extinction of, say, twenty out of twenty-one burners cannot have the effect of causing the single one left to flare and sing; or, conversely, if an additional number of lights be started, the result is simply to decrease the pressure above the valve more rapidly, and allow of a quicker flow from below, which soon restores the proper equilibrium.

The gas, we have stated, passes under the conical valve, C. It then rises through the chamber and escapes by the delivering main, G, depositing in its course any impurities which it may hold in suspension, which, naturally falling to the bottom of the chamber, between the walls of the latter and the diaphragm, B, are subsequently drawn off by the cock, H. The shape of the diaphragm and consequent location of this cock may be altered to suit conditions of accessibility, &c. It doubtless has been surmised that the escape of a strong current by the valve would,




CASEMENT'S PRESSURE REGULATOR FOR FLUIDS.

when the gas is first admitted, produce a vibratory motion or chattering of the valve. To avoid this the inventor supplies a push pin, I, which is pressed down by the flange and held by the weight, J, above it, until its lower extremity strikes the valve stem, thus steadying the latter until the gas has entered the distributing mains, and the proper conditions of pressure above and below the valve result. The pin is then released, when it returns to its normal position.

Another application of the device, essentially the same, though differing somewhat in construction, is shown in fig. 3. The apparatus is here placed in the main leading from the gasometer. The latter is weighted or otherwise arranged to give the fullest pressure ever necessary, and the regulator governs the quantity of that force required for existing needs. The mains A A enter a box which is divided into two compartments, as shown. In the diaphragm the valve B is seated, and the area of its face is made sufficiently large to compensate for the low pressure coming from the holder; or about equal to, or perhaps a little greater in diameter than, that of the main. C C are the weights, and D the push pin, acting exactly as above described. E is the cock for drawing off deposits, &c. Of course the advantages of this adaptation are about the same as already described, only more extended. For instance, if we lived next door to a theatre or hall in which a thousand burners were nightly lit, this wholesale illumination, the inventor tells us, would be without effect on the dozen or so lights in our dwelling. It has also been suggested that the regulator might be advantageously located in various quarters of a city, so as to regulate the supply of gas—or water, just as well—in accordance with the extent of the demand.

In fig. 4 we show an application of the device toward the regulating of the descent of water in pipes down mountain sides. Commencing at the summit, it is proposed to place a regulator A, at a point in the pipe where the water attains a pressure, say of 120 lbs. so as to reduce the latter to 20 lbs. Then, further down, after the water again assumes the first-mentioned pressure, a second regulator B is located, and the force is a second time reduced. This is continued until the descent is complete. By this means the water can be safely carried down any declivity, however long and steep, without undue strain or injury to the pipes.

Our large illustration is intended to show how the invention may be applied to regulating the water supply of an entire city, so as to change the pressure in the mains to the high force useful in throwing streams for extinguishing fires, from the working pressure ordinarily employed. This may be adapted to the Holly system of water works, in which the water is pumped directly from the river by powerful engines usually constructed in substantial buildings on the banks, and of the type represented in our engraving, and subsequently driven through the distributing mains. The idea in this case is to divide the main into two branches which are afterwards reunited. In each branch a regulator is placed, and through each the water may be directed by opening or closing the valves shown. The regulator in the fire pressure branch is adjusted to pass a powerful stream, while that in the other admits of the escape of a current of a force just necessary to insure the complete distribution of the water to all parts of the town.

Another advantage which the inventor claims is that the pressure is equalized throughout the entire system of pipes, so that the latter may be of a uniform strength over their extent, and not subjected to undue strains at any point beyond the valves.

We have now cited sufficient modes of application of the invention to give our readers a fair idea of its value and uses. The inventor informs us that he has made it the subject of practical tests with invariably successful results, and that it has been in operation in his own dwelling, as we before stated, regulating the flow of his gas well for some time past. He is enabled to gauge just the pressure he requires, either for fires or lights, by suitable arrangements of pipes and differently adjusted regulators. The device is susceptible of ready adaptation to the purposes of a safety valve for steam boilers, for regulating the water pressure in cooking ranges, water backs, &c., or the pressure of compressed air or vapours.

## ARTIZANS' REPORT UPON THE VIENNA EXHIBITION.[1]

(*Continued from p.* 337.)

THE second part of this volume consists of the reports of the artizans representing the Birmingham Chamber of Commerce, and reflects equal credit upon the general energy of the great manufacturing town, and the singular enterprise of private individuals. In reply to their advertisements, the Chamber of Commerce received eighty-eight applications. From these, ten reporters were chosen. The expenses of three more were defrayed by their employers, and two, in addition, went entirely at their own cost. These reporters, fifteen in all then, were attended by Mr. W. C. Aitken, who subsequently revised their returns.

As before, we shall select such passages as best serve as examples to our English workers, omitting necessarily all mention of familiar processes, and paying especial attention to those branches of manufacture upon which the Birmingham men are peculiarly fitted to report.

### JEWELLERY: CHIEFLY CONCERNING ITS MANUFACTURE.

*Turkish Jewellery.*

The Turkish jewellery was of a similar character to the Egyptian, but better made, with a higher class of finish. The small coins and pieces of flat metal connected to chains formed the leading idea. The settings of turquoises were more frequent and the combinations better, forming in some instances the centre to a flower, and used as studs for apparent fastenings in parts of the work. There was also a large example of filigree work in the form of a shield; the disc of metal to which the filigree was attached was silver whitened, ornamented with parts in gold, and further decorated by the introduction of rubies and turquoises. The leading forms worked in the filigree were birds and leaves, and the spaces filled in with scrolls. The whole of the filigree enrichment is made of twisted wires, not as most of the English filigree, *i.e.* of a single wire notched or knurled on the edges by means of a pair of rolls; the former has a very much more artistic appearance when properly worked up, but the latter has the advantage of fitting closer, is easier worked, and made more quickly.

*Greek Jewellery.*

In the Greek collection, which was very limited, were some waistbands, made of plain strips of silver, with wire-work studs at intervals: also some large silver buckles and clasps for waistbands used in connection with ribbons; these were very white, neat, and cleanly finished.

*Russian Jewellery.*

The exhibits from Russia were very characteristic, consisting of large bracelets square and massive, the band flat, the edges square, the ornament built up of parts in a compact form, requiring, by its close conformation, some good fitting, which was successfully accomplished in the article examined. Most of the jewellery exhibited was in suites, decorated with enamels of green and dark blue; others were ornamented with what is technically termed "gallery," viz., a narrow perforated piece of gold resembling a neat wire pattern; portions of strips of gold forming some of the ornaments were lightened by saw-piercing a neat scroll pattern in them. The whole of the examples were in the severe and massive style peculiar to the Russians, yet all were in good taste, all, while indicating strength, showed a clean and neat finish.

*Italian Jewellery.*

The proper art of the goldsmith was well represented from Italy, by Castellani, by Geraldini, and others, the chief feature in the collection being the great use made of wire. The greater part of the articles exhibited is covered with ornamental wire work, made out of both plain and twisted wires, bent into beautiful shapes, and laid on the plain surfaces with such cleanliness as to render the detection of any marks of solder very difficult. The forms used were very few and simple, and yet by the different applications and combinations of these, beautiful designs were produced. There was a marked absence of anything extravagant or of any effort to produce anything very novel, but a free rendering of ancient classical forms in a variety of designs. These designs embraced some very rich mountings to cameos (for which Italy is famous), consisting of a deep massive border, either with a straight square edge, filled up with

[1] Published by the "Society for the Promotion of Scientific Industry," Manchester.

twisted wires of different sizes, the front sloping towards the centre, and containing a small fine design in scrolls of plain wire, or a deep round border, ornamented with wires of different descriptions. Some brooches had for a centre the ram's-head (evidently cast), wrought very full, surrounded with a border covered to a great extent with fine ornaments of plain wire. Earrings of an ancient form were shown, representing, in some instances, a female head and bust, the lower part of the figure ending in a flowing leafy scroll, which curled up at the back and terminated in the wire forming the loop. The colour of the gold is a very dead yellow, with no attempt at brightness or relief on any part; this harmonizes with this style of work very well. The surface ornamentation being very low, and the shapes usually of a solid form, give a depth and body well in harmony with the whole character of the articles.

The design of the different pieces appears to be well carried out, evidencing skill and artistic knowledge; but in what we should call mechanical skill and finish in the construction, the Italian workman is deficient. The pose and effect is carried out to perfection, but, in the matter of close fitting, or truth in the regulation of parts, why, that is mechanical and not artistic, and so it is rather carelessly done. Compare the Italian with the English workman in this respect; the Italian fascinates with the front of a brooch, and disgusts with the back; the English will more likely please with the back than the front. My meaning is that to a good Italian brooch will be found a weak fitting pin and a bad fitting box, pieces of solder on which should have been cleaned off. In a good English-made brooch, the back is cared for as much as the front, and will bear as close an inspection.

*Swiss Jewellery.*

The Swiss jewellery chiefly consisted of châtelaines or watch pendants, having no very distinct style or character, but embracing examples of all styles, both ancient and modern; some of these exhibited under Swiss names were made in Paris.

A large number of the commoner and inferior kinds were made of silver, oxidized; the designs of these partook largely of strap and broad ribbon work; they had a very heavy appearance; some, which were of a light kind of ornament, built up into a suitable form, displayed more taste. The gold examples exhibited were in a much better style, being very light, graceful, and embellished with leaves and flowers formed from red, green, and yellow coloured gold; platinum was also introduced, producing by a simple arrangement a very good effect. One of the chief attractions in the collection were the examples of châtelaines attached to watch cases, ornamented in a similar style. These were in different styles of ornament, as Greek, Roman, Egyptian, and Renaissance, wrought out in the full character of the various periods they illustrated; enamels and precious stones being introduced. These were executed in a very finished manner; the figures or ornaments were sharply defined and well wrought out by the workmen. These examples were quite unique of their kind, having nothing to compare with them in the whole range of the jewellery exhibits.

In a higher class were some châtelaines of much finer quality; these were attached to watches of superb make and finish as far as the goldsmith's work was concerned, and comprised a pair of birds of Paradise, with the tails thrown up, connected with a neat ribbon work set with brilliants; the birds set with precious stones all over, comprising diamonds, sapphires, rubies, and emeralds. The design of one example consisted of dolphins artistically entwined and beautifully set with stones, in a similar manner. Another example was a serpent designed in a beautifully convoluted coil; this, also, covered with gems of different colours. The workmanship in these examples appeared to be excellent; the forms were well worked out, the settings close, the stones well cut, and the colours of the stones harmonized well and were of excellent quality.

The manufacture of châtelaines to such an extent is a somewhat new feature in jewellery. Among the Swiss these articles have received their earnest attention, owing (of course) to their extensive watch trade. For the infinite variety and perfection of the manufacture of these châtelaines the Swiss deserve much praise.

*Spanish Jewellery.*

The Spanish collection was a very small one, consisting only of a few examples of gold filigree work of an ordinary kind, and of a very dull yellow colour.

*Austrian Jewellery.*

The Austrian exhibits have astonished the world, and in no one department more than in the jewellery exhibited. Had the quality been ever so inferior, the number of articles exhibited would have been a redeeming feature. It seemed as though nearly every jeweller in Vienna had determined to make some show, whether it were advantageous or not, and as a result there was a great deal of repetition, which it would have been better to have avoided. While the large numbers exhibited gave a better knowledge of the productive power of the Austrian jewellers, it did not give an exalted idea of their excellence. In the display made there was room for jewellery of all materials and kinds to be shown, and this was accomplished; it embraced every article which could be included under the definition of jewellery, from a common ivory solitaire up to a diamond tiara.

In ivory, tortoiseshell and meerschaum were a large collection of small trinkets, solitaires, studs, &c. The solitaires were much larger than we are accustomed to; some oval-formed were two inches long, and of a proportionate width; also some round nearly as large, turned in different shapes, plain, lunette, grooved, or as a broad tapering cone; others were engraved, the cut-out parts stained with black or blue colour; others, inlaid with monograms in gold or silver and neat ornaments, looked very chaste and pretty. In this class of articles a large quantity of amber was used. The amber being transparent, and susceptible of a high polish, made some very attractive articles. In the chains made of amber the effect was not so good; though there was a variety in the pattern of the link, yet such chains had a thick and clumsy appearance.

The examples of gilt jewellery were good in design and style, though entirely produced from dies, but in the execution coarse and rough, the surfaces being left from the die, without being polished; the grain of the metal was exposed along with any defect which might have been on the surface of the die. Some of these articles showed a very good attempt at a dead yellow gild, in imitation of the deep dead colour given to the best gold work, though it could be easily detected as an imitation on account of the coarse granular surface (produced by the action of the acid in depositing the gold). In the ornamentation there was a great deal of "lapped" or bright surface, making a cheap article, stylish and showy looking. For style, design, and taste, they were superior to English-made goods of the same class and price; for strength and general workmanship, they were inferior.

In silver all kinds of trinkets and articles of jewellery were exhibited, freely covered with enamel, and largely ornamented with niello. Niello has been used in large silver pieces for a very long time, but its introduction into small articles of jewellery is a new feature. In connection with silver it forms a very nice contrast, and is capable of being applied to a very much greater number of articles than it has hitherto been, especially as its application is so simple and easy. The articles to which niello was applied were mostly with plain surfaces, on which ornamental lines, flowers, and scrolls were introduced. The pattern for the reception of the niello is either engraved on the surface of the article to be nielloed, or the indentation to hold the niello is produced in the die in which the "blank" is stamped; the niello is placed in, fired, then ground; and the work is finally polished all over.

In passing on to the gold jewellery, it is necessary to observe, as a rule, in coloured gold only two qualities are used; these are either assayed or guaranteed to be 14 or 18-carat quality. This rule is of rather recent introduction, and is well observed, especially among the leading jewellers of Vienna, who find it to their mutual advantage to have the gold of reliable quality in their work, so that, in competition, they are on equal terms. So much is this observed that every part of an article guaranteed must be of the guaranteed quality. As an example, the following instance may be stated: some breast-pins of 18-carat quality were sent from England, with stems made of bright, or 9-carat gold—a custom that is universal with us in England—adopted on account of the harder nature of the alloyed gold being better adapted for the pin. They were refused until the proper alteration was made. In the boxes at the back of brooches and pendants, the same strictness is observed, and a great many of them are joined or made so as to open, that the jewel may be proved to be of genuine metal.

Another advantage in the large use of 18-carat gold is the better colour obtained on the work. The best Viennese gold jewellery in this respect is very superior, having a soft, smooth, dead surface, with what we term a "satin bloom;" not a speckled granular ground like that some "colourers" produce accidentally in trying to obtain a dead frosted appearance, nor the light bright polish common to the cheap English jewellery. The excellence of colour is to a large extent entirely due to the better quality of gold; the action of the acids and salts used in the colouring not affecting the surface of the better quality gold to the same extent as the inferior. Of course, as is well known, the process of colouring gold is to decompose the gold and its alloys; this process is only continued long enough to dissolve the alloys (silver and copper), thus leaving a film of pure gold on the surface of the article. The better the quality of gold, the less the surface is destroyed; 14-carat gold is about the lowest

quality of alloyed gold upon which a good colour is obtainable, but in England a large quantity of jewellery is coloured of a much lower quality.

The forms and shapes of the Viennese jewellery were very varied, but the majority of the pieces had a combination of bright and coloured gold; the bright parts worked in small lines of relief, as in the centre of a brooch or bracelet, these being the highest parts; coming from under it all round there is a thin plate of bright gold, showing a line about one-sixteenth of an inch wide, and towards the edge of the article this is repeated again.

But the most chaste and finished articles were in the case of F. Hartung; they were not the largest or most costly, but every article in it was excellent, and displayed to great advantage. Plenty of space was given to each article. The case was lined with dark purple velvet. There were no very large stones, but what there were, were of first quality. No massive pieces of jewellery were exhibited in this case, but in brooches, bracelets, earrings, and other ornaments there was a very close attention to small details, and very great perfection in finish. Among other special articles of jewellery a nearly naturalistic representation of a dragon-fly, the thin body of which was set so close as to resemble almost one stone, covered with miniature facets; the wings set with diamonds, and yet altogether devoid of the heavy appearance usually attached to diamond work. Some fine onyx cameos were also mounted on a light open spray, set with diamonds falling round it, the stones having no bezel or apparent attachment, yet the leaves were so arranged that by touching the stone in different parts, they afforded a firm setting for it.

A brooch with large sapphire centre, and an ornamental diamond border surrounding it, forming the outside rim of the brooch, the space between the border and the stone filled in with an open piercing of scrolls, very fine, in red gold, and set with rose diamonds, had a very chaste and beautiful appearance.

There were several other articles that well merit description; in the whole of them the arrangement of the stones and the setting was of excellent quality; the gold cut away clean and clear from the stone; and the stones were so arranged that the whole space was filled up; no spare gold to be seen but what was thoroughly necessary; the grains rounded, clear, and bright, like miniature burnished beads.

### *German Jewellery.*

The German collection in general character is very similar to the Austrian, but not so large, nor exhibiting such costly gems. The greater part was good coloured gold work of very excellent quality and finish. The colour in some of the exhibits was remarkably clear and fine, of a very soft dead colour. Most of the work appears to be stamped in dies; and this, with the truly novel and excellent designs adopted, enables them to produce a bold vigorous-looking article at a much smaller cost than if wholly made up by hand. Most of the articles have great simplicity about them; the idea is very apparent and well wrought out. There is a very similar use made of bright lines of relief, as has been already described as noticeable in the Austrian jewellery.

Some bracelets made up of tablets were exhibited, that is, square or other shaped pieces jointed together. The forms used were chiefly square or octagonal, forming when united together a handsome and massive looking bracelet. These were well made and fitted together, the joints being kept well out of sight.

Among the enamelled exhibits were some antique crosses, inlaid with different colours of enamel, applied in various designs; on some were mediæval heads and figures of a different character. Also some specimens of translucent enamel on butterflies, small solitaires, and studs of very brilliant colour. There was a novelty, or what appeared to me a novelty, in some thimbles of gold and silver; there were introduced, as substitutes for the usual metal tips, pieces of agate and amethyst, cut to the shape and set in, having small holes drilled in the stone similar to those in the ordinary thimble. These stone-set examples united beauty and durability.

### *French Jewellery.*

The French collection had the peculiarity of the predominance of bright red gold, worked into shapes and styles quite different to the old red gold articles; they were for the most part thin, wiry-looking ornaments, arranged into a pretty-looking form, interspersed in parts with coloured gold, but had a frail and tinselly appearance; all these ornaments are produced in dies and sold to the French jewellers by eminent firms, who cultivate this branch of trade as their exclusive business. One firm of the name of Decaux exhibited these "blanks" in the rough, as they leave the dies, and very beautiful things they produce; these are purchased at a small percentage above the cost of the gold, by the smaller jewellers, who put them together, and produce a pretty article at a cheap rate. There is among the French jewellers a constant effort after originality, a straining to bring out something new; in doing so they are aided by the natural artistic genius they possess in a very high degree, enabling them to set aside precedent and past historic models of art, to attempt to create or create a style for themselves, and thus they show a greater boldness in working out an idea than Englishmen. Many of the exhibits were of a different character, the designers referring to antiquity for their inspiration; chaste and classical examples of jewellery in the antique style, as brooches, earrings, and bracelets, demonstrated their assimilative power and genius; some of these were worked out by having a coloured gold ground, with oxidized figures thrown up in relief upon it; others, in the Renaissance style, were well carried out in different coloured gold in combination with platinum. These had a much more subdued and refined appearance than most of the exhibits.

There were also several splendid specimens of diamond work remarkable for purity of the stone, lightness of construction, and elegance of design, apparently perfect in finish, and very superior examples of setting.

## Metallic Tubing, Rolled Metal, &c.

Speaking generally of this class of manufactures exhibited in the Vienna Exhibition of 1873, I am decidedly of opinion that the foreign productions (with the exception of one particular instance to be presently noticed) are in no way superior to what is produced in England, the town of Birmingham especially.

In most cases (France excepted) there is a want of finish about the work, which, while it has no additional claim to notice as regards solidity or excellency of construction, makes it compare most unfavourably with our own productions. To say the least, the latter claim attention for a full maximum of substantial workmanship, whilst the amount of finish displayed is, in nine cases out of ten, far before that of any foreign house as represented at the Exhibition.

Most prominent amongst the French houses stand Messrs. J. J. Lavoissière et Fils, Paris. This is the firm I alluded to in my introductory remarks as furnishing an exception to the general quality of the workmanship displayed at the Vienna Exhibition. They have a grand display of tubes, built up in the shape of a square tower, with a turret at four angles, and a passage in it which visitors passed through, and examined their display. The tubes are all seamless, of all sizes, varying from about $\frac{1}{8}$ in. to 17 in. diameter, and from 10 ft. to 20 ft. long. The 17-in. diameter tube was over 20 ft. in length, and is in itself a splendid example of what may be effected in this particular branch of manufacture. Perhaps the great majority of tubes exhibited at this stand are from $1\frac{1}{4}$ in. to 6 in. diameter, but, whatever their size, they exhibit a marked excellence as regards manipulation; they are, in fact, perfect specimens of their class —without dents, clear in surface, free from scratches, and straight as arrows. They also showed a class of copper tubes, bulged in the "centres," from $\frac{1}{8}$ in. to $1\frac{1}{2}$ in. diameter; but for what purpose they are required I am unable to conjecture. Tubes of this kind illustrate the fineness and malleability of the metal of which they are made. This firm shows a great superiority over other houses as regards the size of their products, as well as for the quality of their workmanship. They supersede the English tube manufacturers in the former particular, while the skilled labour exhibited in the ordinary sizes bears about the same comparison. It is a first-rate stand of tubes, and these, taken as a whole, are far in advance (as regards diameter) of any seamless tubes we produce.

## Cabinet and General Brass Foundry.

### *Austrian Brass Foundry.*

In examining the various articles, my attention was arrested by the very great number of lock handles for doors, in the Austrian and other courts, of a different form to those made and used in England (viz., the ordinary door knob), which with us are generally round and smooth, the worst possible form to overcome any friction when the lock does not work freely. The handles which I allude to, so generally in use in Vienna, are of a cranked or bent form, the leverage or increase of power which can be applied to the cranked handle (over the knob) being very much greater, demonstrating its superiority; it also admits of an opportunity for the display of ornament, which the knob form cannot. The handle is, in form, simply a crank or right-angular piece of metal, the short leg of which is fitted on to the lock spindle, the longer leg, or lever to which the pressure of the hand is applied, by which the bolt of the lock or latch is turned, being from 3 in. to 4 in. long. The rose and escutcheon plates are united in one piece, outline ornamental and surface plain.

The castings were good clear work, free from specks and sand-holes; the finish (either burnished or polished) was of good quality.

Other examples of a superior quality, more bold and massive, were ornamental, the design and ornamentation generally being such as not to render the cranked handle unpleasant for grasping; this principle is carried out in very much of their work with success. The style of ornament most prevalent in this variety was a free treatment of foliage after the Renaissance style. Some of the best ornamental work was well got up in the various bronzes of steel and copper colour, some being bright dipped, lacquered gold colour, and finished in good workmanlike style.

Of hinges exhibited, those known to the trade as the "heave off" preponderated, being used for the kind of windows known as French casements, for the convenience of cleaning them when required, some of the largest and best being about 10 in. long, with ornamental joints of about 1 in. diameter, with knobs to match at top and bottom. The flaps were long and of bracket-like shape, and covered with tastefully modelled scroll-work, cast in bronze, dipped bright: a very good hinge, its only weakness being the pin, which was too small in proportion to the size of the hinge joint. A great quantity of the hinges exhibited were in iron, the joints and flap covered with a thin case or covering of brass. Some with knobs looked like good work, the brass being even upon the surface and polished; others also of the same class of article, but not of such good workmanship. The expense of fixing the brass upon the iron would add somewhat to the cost; nevertheless I think it worth the consideration of manufacturers of hinges whether an article to come between the iron hinge and the "all brass" could be produced, which would last much longer than the cheap brass hinges of Birmingham make.

*French Work.*

In lock handles there was not so great a display as in the Austrian court; yet some of those exhibited were very good examples of art work, the bronzes introduced on the examples shown being very good in colour, as also were those "dipped bright."

Of door handles there were an excellent variety, both in point of design and finish, more so than those of Austria or Russia; some of the handles of a good useful kind, used sometimes to fix upon the centre of the door, like the centre knob with us; the examples of this kind being larger and bolder in every way than the regular English door handle. They were both straight and bent gripes, cast, and of tube, the roses, standards, and gripes modelled in good bold forms, in same style as the lock handles, and finished in the various colours of bronze and gold of first-rate quality.

The chief features of this court are the examples of high art, shown in a great variety of brass work for ornamental and decorative purposes, as vases, large and small stands, time-pieces, and balustrades of good design, in the Italian style, bronzed, black, and copper coloured, others finished bright, like those of Austria previously described, but a much greater variety of all the styles of finish for which the French are celebrated, and deservedly so.

The examples of hinges with ornamental joints were of good design and workmanship, similar to the work previously named, and of equal merit. Some iron hinges with thin brass cover, or cased like those of Austria, and of the same quality of work, were also shown.

### Table and Ornamental Glass.

*Italian Department.*

One of the most striking and wonderful parts of the Exhibition, is that of the revival of the ancient art of glass-making by Dr. Salviati and Co., of Venice. The beauty of their colours, and lightness of their "metals," is peculiarly worthy of great praise. We take, for example, one of their wine glasses. The bowl is supported by a group of the most beautiful flowers and leaves it is possible to conceive. The design is founded upon the form of the delicate snowdrop; the weight of the glass is not more than an ounce and a half. A goblet with flat twisted stem, like a corkscrew, the edge of the twisted ribbon of glass adorned with the most delicate "pincing" it is possible to "run;" the stem is attached to a ribbed knob, placed on the back of a beautiful white swan, the grace of the bend of the neck of which was one of the most artistic features; the foot of the goblet was threaded with aventurine, and the top of the bowl also, and yet the goblet only weighed 3½ oz.; the body of the swan was blown in the ordinary way, a piece of metal then "gathered" and sunk in the body, which was pulled up, curved, and shaped to form the neck. A small flower vase, light blue, and ribbed in a mould threaded at the top and bottom with "aventurine," with four small knobs in the neck, and globe body with light foot; on each side were attached four small handles to each knob; there also small "pincings" running down the four handles. It is one of the most beautiful pieces of glass-work I ever saw, so neatly, skilfully, and delicately blown; not only is the blowing exquisite, but its artistic merit is in harmony. The handles are of flint glass, also pinced. The conception of this vase is masterly and artistic, a great credit to the workman for the ingenuity displayed. So delicate are the small parts, that many workmen in the trade would think that they were not or would have been produced in the glass-house. There is a large flower basket made of glass, about 14 in. in diameter, filled with a beautiful assortment of flowers and grass, all made in glass, placed in the basket just as if they were fresh gathered. There are flowers of every kind, with different colours and shades of colours, so beautifully put together, that my fellow workmen would think it impossible that they were artificially made. There is also a flower vase stand composed of three different receptacles to hold the flowers: one of the latter is delicate opal, the other ruby, and another light blue, threaded with "aventurine" on the lips; the three flower-holders are attached together as a trefoil by means of small pieces of flint glass. To cover the connection of the flower holders to the stalk, there are beautiful butterflies, with their wings stretched out, apparently holding the three flower holders. So artistically are the wings made to touch the vase, the body of each butterfly so curved to give life and force, they seem as if they were going to fly away from the place they rested on. The wings of the butterflies are variegated with the most beautiful colours it is possible for even nature to give. This stand is placed in a dish of light-coloured glass. This is only one of the many great conceptions which prove the ability of Salviati and Co. to produce the most perfect specimens of the glassmaker's art. There is scarcely anything in nature but what they can produce, as flowers, flies, ducks, dolphins, snakes, and other animals, too numerous to mention, created and introduced on the works made by these celebrated Venetian glass-makers.

There is also another of the most wonderful triumphs of art in glass-blowing that man can conceive (a tazza), which I wish to describe. The bowl of it is composed of the beautiful gold-coloured glass, called aventurine, and of threads of white and light-blue glass, plaited together as truly as if they were woven. The bowl rests on three scrolls made in flint glass, the edges threaded with ruby. Resting on these scrolls are dolphins, with the tail of each supporting the bowl. The dolphins are not "moulded," as we should make them in this country; they are blown by the glass-maker, the fins and the eyes put on while in the course of making; they are beautiful and light, and their colour delightful. There is not a gem got from the bowels of the earth, but what the Venetians have copied the exact colour. There are colours produced in Venice which we in England have never seen in glass.

The jugs of Salviati and Co. are very beautiful in shape, some of them most difficult to make. The handles of these are made before the body; they are made like a scroll, and then attached by two small pieces of flint glass while the body of the jug is being made. The Venetians were the first to introduce the star-sectioned form of handle into Europe. There was a jug 12 in. in height; its body was made and moulded in an 18 in. ribbed mould, and thereafter ornamented with leaves, flowers, and fruit. The flowers and leaves are attached by means of small pieces of flint glass. These flowers, &c., are artistically arranged round the body; and are tipt with the beautiful colours and tints only seen in Venetian glass. The colour and twistings of the leaves are grand masterpieces of skill and ingenuity.

There is a great error entertained in this country by glass-blowers, viz., that the Venetians make a great deal by means of the "lamp." It is not so. The attachment of the several pieces which make up Venetian work is all done in the glass-house. They have pincers to "pince" the most delicate flowers and leaves, and as they are continually in the practice of "pincing," their tools are made more carefully and smaller than ours; they also use them more freely and skilfully, and accomplish thereby works which excite our wonder. I had the pleasure of being introduced to Dr. Salviati by Mr. Aitken and Professor Archer. He told me that two of his best workmen were descended from families which had been connected with the glass trade of Venice for more than 300 years.

At Murano there is a special museum for glass, which contains examples of Venetian make, some of which are very old. If a workman has any difficulty, he at once goes to the museum; so they have all in their favour.

*French Department.*

The glass exhibited consists only of samples of sheet glass blown in cylinders, 10 ft. long and about 12 in. diameter. Professor Archer directed my attention to these cylinders, and led

me to understand they were produced by mechanical means used in blowing them; they are beautifully cylindrical, and are of the same thickness throughout. The shades the French exhibited are well blown, clear, and large; the milk-pans shown are well made, some of them made so that you can get a firm hold, by the maker attaching a piece of glass on each side under the welt.

*American Glass.*

In this department there are some splendid specimens of show glasses for exhibiting seeds and confectionery; also, bottles for containing drugs. They are splendid examples of glass blowing, the designs good, and the several articles well made. I should like to have examined some of their table glass, but there was none exhibited, and only a few examples of "pressed" glass (but not exhibited by a manufacturer); these consisted of wines, goblets, and a few jugs. The show-glass covers were well made, some of them produced by pressing the heated glass into metal moulds; the colour of the metal is good.

Large sums have been expended by the Americans in the invention of presses and machinery to press the semi-fluid glass when heated. The glass-pressing process has revolutionized the whole system of the flint-glass manufacture; many of the articles produced by pressing closely resemble cut work, only the practised eye can detect the difference. The tendency has been so to reduce the cost of glass articles that its consumption has increased tenfold. The Americans claim the invention of the machinery employed, and I believe they were the first to produce articles by pressing. The process has absorbed the surplus labour in the glass trade, and some of the makers prefer it.

## Guns and Pistols.

*America.*

Peabody, Sharp, Colt, Remington, Smith and Wesson, and the Springfield Armoury are all well represented. The first thing which strikes the professional eye is the absence of that workmanlike neatness and finish which we are accustomed to in work of corresponding quality. The military arms, for instance, have an appearance of what we should call "rough work," in comparison with the high-class article turned out from our armouries; and in shape, their clumsy, heavy, even ugly appearance almost offends the eye. Still, to pass them by with such remark would be to do them great injustice. There is in the American work such an evident adaptation of means to ends, such a direct aim at the *use* to be made of the weapon and its various parts, such a palpable thrusting aside of all considerations but those of serviceableness and durability, that the merest glance below the surface impresses one strongly with the thoroughly practical character of the transatlantic mind. The things may be unsightly, but we feel that they are sound; they may not please the eye, but we know that they will answer the purpose for which they are designed. There is the same air of blunt sincerity and contempt of all disguise about the American work which is said to characterise the Western settlers. It seems to say, "Here am I, just what I appear to be; take me or leave me." A screw head is an unmistakable screw-head; that and nothing more. It is not polished off level with the plate in which it lies, nor is it deceptively made to appear a part of the engraved design. It stands up clumsily from the surface, or it lies buried a little below it, just as it happens, and it may, or may not, fit the hole it lies in. But it looks like a good honest screw, and we may rest assured there is a well-cut thread at the other end. It must not be supposed that all American work is obtrusively coarse. The small Deringer, and Smith and Wesson's pistols are models of nattiness and handiness; but about them there is clearly nothing that is gimcrack; they are weapons, not toys; they are (alas!) for use, and not for show.

Some parts of military weapons, shown in various stages of completion, from the machines of the Springfield Armoury, have the same want of clean finish, but an abundant evidence of sound, rough, serviceable, solid work. Some day or other, perhaps, our American cousins will begin to pride themselves upon the appearance of their really meritorious productions, in which case the more accomplished of our artisans, of whom, unhappily, there are often many to spare, will be at a premium amongst them.

*Great Britain.*

The whole gun-making trade of the greatest gun-making country in the world is really represented by one firm. There are some half-dozen double breechloading shot guns by Alfred Lancaster; a trophy of barrels by the Henry Barrel Company; one or two military rifles by Soper, which are said to have been loaded and fired sixty times in one minute; one or two again by Henry, showing his self-cocking action and side-lock systems; and beyond these few, exhibited as they are mostly for specialities, the burden of sustaining the credit of England, for her extensive and various gun manufacture, home and foreign, falls on Webley, of Birmingham. Other Birmingham guns there certainly are in the Catalogue, but after a weary search I became convinced that they were only in the Catalogue. It is not my province to play the critic on the works of any individual manufacturer, but, while carefully avoiding the province of a juror, it is perfectly allowable for me to say, what it would be an unpardonable injustice not to say, that in Messrs. Webley's case the gun trade of England is worthily represented. It is represented, as regards variety, by specimens of nearly all the principal types of arms produced in the great Midland armoury. It is represented, as regards quality, by a sufficient sprinkling of those high-class weapons, for the production of which England yet stands unrivalled, which combine all the possible excellencies of use with the most absolute perfection of finish, and which yet have not about them one single line of ornament that is superfluous or meretricious.

*Belgium.*

My impression is confirmed that the Belgians are great copyists, little more. They take up every new idea as it comes out, and sometimes plod away till they make a success out of it, but sometimes they are found wearily following a lead that everybody but themselves has abandoned long before. In one branch, however—and this, again, is a thing I formerly remarked—they seem quite up to the times, viz., in the manufacture of revolvers. Parts of these are shown, in various stages, from the machines; and so nicely have the cutters performed their work, that very little remains for the hand-filer to do. We can see how it is that they have cut us out so completely in this branch—at least, in that part of it which consists in producing a neat, handy implement, and a somewhat complicated piece of mechanism, at a low price. They have had the start—they have got their machinery into good working order, and on a sufficiently large scale, and they have passed through all the preliminary difficulties of getting labour into harmony with the new conditions. There is nothing in all this that we could not do if we tried; but two or three fortunes would be sunk before we could get into the market with them, and meanwhile they are covering all the demand, and there is no inducement to try. Thus it comes about that Belgium has all but a monopoly in making a certain class of cheap revolvers; a monopoly even encouraged by our gun-makers, who purchase them largely in the filed state, have them proved and finished in England, and sell them as English-made. For the general market they suit admirably well; they have a sharp, agreeable action, a neat appearance, and present a great variety of construction. The 12-shot or 20-shot revolver is a bit of a wonder in its way, and it would seem a great wonder if the purchaser knew at what price it was originally turned out from the warehouses of Liège. National supremacies in particular walks of industry are often begun in this way. An individual manufacturer, with more ingenuity, courage, or foresight than the rest, begins a new trade. Others round him follow him up directly they perceive his successes. The thing grows, and before the world is aware, they have got such a hold upon the market that it is worth nobody's while to go against them.

These revolvers are too light for military use, but the Belgians are now turning their attention to producing strong, serviceable weapons, and no doubt will, in time, compete with us in all the markets. There is one exhibited which seems a sensible, solid article. The stock turns upon a hinge, and then the side-plate can be moved round on a pivot, leaving the works exposed. It is handy for oiling, &c. This revolver boasts to have fewer pieces than that of Galard.

In the Belgian department are some guns and parts of guns made of phosphor-bronze, a rich-looking material, almost as much so as aluminium bronze. On looking at the case and seeing such things as chisels, scissors, and other cutting instruments, made of the same alloy, I wondered for a moment whether the long-buried secret of the bronze ages had been brought to light again—the secret of tempering brass to bear an edge, which it is said the older nations possessed when iron and steel were unknown. I had no opportunity of finding out how far it had been found applicable to such purposes; but with regard to its use in fire-arms, I was afterwards led to understand that a few awkward explosions, occurring after the metal had been supposed to be fully proved and tested, had effectually exploded its pretensions.

The prices affixed to some of the guns seemed to me rather high. A breech-loading double gun, very plain indeed, was marked £6; a muzzle-loader of the same quality, £2 16s. I am afraid there is not much reliance to be placed on these Exhibition prices; they probably do not represent the manufacturer's wholesale prices, but the retail price of the shopkeeper, the manu-

facturers' wholesale customer, who would be offended if his profits were exposed. I know an instance of a manufacturer showing in an International Exhibition who was obliged to reprice all his goods at the dictum of a powerful customer, he having innocently ticketed them, in the first instance, at the price at which he sold to the said customer.

The military guns shown are of all conceivable systems, and if they represent faithfully the work actually done in the factories, their trade must be extensive and various indeed. I took down the names of more than fifty different breech-loaders in one case, muskets and carbines. It would be an utter waste of time for me to describe them. Most of them are well known here; indeed, some of them seemed to me very suspiciously like English make. But if it were not strictly a case of manufacturers' patterns, but a collection of the best known arms, in the nature of a museum, the sending it there was a piece of enterprise which rather took the shine out of *us*.

Large as it is, there is not much to gather from this department. Some of the best work might give us a wrinkle, as, for instance, the get-up of their barrels, ribbed all round, or rather fluted, with chasing on the edges. It looks very rich, but after all, the style is most suitable to those ornamental arms in which we take little delight. The general features of the Austrian work are heaviness and richness. All are more or less showy, and all are heavy and lumpy, especially about the butt.

*Russia.*

We come upon a small collection of military rifles, systems Krink and Berdan. The Krink is something like the Snider, but the block requires to be thrown over quickly, and then it jerks out the cartridge case. Another fact the Exhibition brings out strongly—that breech-loading is the universal order of the day. Not a single national weapon is shown of the old muzzle-loading type. The science of destruction has kept pace with the other sciences, and the deadly breech-loader has become one of the emblems of civilization.

## Labour-Saving Machines.

*America.*

Messrs. Sharp and Brown, and also the Pratt and Whitney Company, both exhibit their excellent universal milling machines for making cutters and spiral drills of every description; also their screw-making machines, to both of which I referred in my Report of the Paris Exhibition. Both these firms send a few machines for gun-work, which consist of milling, drilling, and profiling machines: the workmanship and proportions of the whole invite the scrutiny of the most biassed competitor.

Messrs. Sellers and Co. show a very superior wheel-cutting machine for spur or worm-gearing. The frame that carries the spindle in the cutter, either vertical or spur, or at any angle, for worm wheels, travels in a horizontal direction, with a quick running back motion, when the work moves by a self-acting arrangement for another tooth to be cut. By the use of change wheels, any pitch may be got; the shape of the tooth is not turned to a template on the cutter in the ordinary way, but is cut on a machine (not exhibited), which ensures the correct shape at the back as well as the front of the tooth, as it cuts the clearance. As the tooth of the cutter is ground on the front by an emery lap, the true shape of the cutter is always preserved.

Baxter D. Whitney exhibits a complete set of machines for making ordinary house-buckets, a detailed description of which would occupy too much space. I may, however, just mention that the staves are cut to the required taper, then hollowed out for the inside, then ploughed on one edge and tongued on the other, put together, turned inside, grooved for the bottom, turned outside, and the bottom cut out and levelled on the edge, entirely by machinery.

*England.*

The next department is Great Britain. Here are wood-cutting machines for builders, joiners, and cabinet-makers' work. England is still in the front rank, but how long it may remain so is difficult to calculate. Although its superiority to all other countries in design and mechanical arrangements is obvious, its strides have not been so great as either Belgium, United Germany, or Austria. This may be accounted for, perhaps, in two ways: the first, and most likely, is, the nearer a thing approaches perfection the less striking is any improvement; secondly, United Germany now numbers among its own, many manufacturers who at the time of the Paris Exhibition were French exhibitors.

*Germany.*

Geschwindt and Co., of Baden, exhibit wood-cutting machinery in general, among which are planing machines for hard wood; these have rollers carrying knives in a diagonal direction on the top of the work. I had not an opportunity of seeing the machine in operation, but the work that was left in the machine was well done. This machine had an adjustable feed motion, which consisted of a disc, driving a roller from its surface; a screw on the end of the spindle carrying the roller renders it capable of being pushed nearer to or further from the centre of the disc; this of course alters the speed of the roller, although the disc travels at a uniform speed. The whole of these machines were strong and well made.

A very excellent machine was shown by A. Esterer, Altotting, Bavaria, for planing twisted flutes in stone columns, &c. This was similar to an iron planing machine in its construction. The work is held in chucks at each end, supported on metal bearings; attached to one end is a toothed wheel which gears into a rack, working transversely with the table of the machine; one end of the rack is made to slide longitudinally along a bar placed horizontally at the side of the machine; this bar has a joint at one end, and the other end can be adjusted to any angle with the bed of the machine. As the work travels backwards and forwards past the tool, the rack slides up and down the bar, which gives it a transverse reciprocating motion, which, conveyed to the wheel attached to the chuck, also gives a similar motion to the work. This arrangement is precisely the same as a gun-rifling machine, and only produces the twist on the work; but in case of columns where the line or surface is not straight, another motion is required to keep the flutes on equal depth; this is accomplished by means of a flat iron bar fixed edgewise and parallel with the work; the edge of this bar is made the same profile as the work; a roller fixed to the vertical slide of the tool-holder works on the edge of this bar, which causes the tool to rise and fall according to the shape of the work, the roller being kept down by a weight on a lever at the back of the tool-holder.

## Railway Carriage and Waggon Building.

*Austria.*

Ringhoffer, of Prague, carriage and waggon builder, exhibits a sleeping saloon. This coach is 23 ft. long, 8 ft. 8 in. wide, at the elbow rails turning under about 3 in., gradually diminishing from the elbow rail. The framework is made of oak, and covered with sheet-iron panels, the panels having a very level surface. The doors are lapplated from top to bottom with very heavy lapplate, measuring 1 in. The hinges are very strong and well made, measuring 3 in. by 4 in., the bottom one larger in proportion to the turn-under of the body. The doors are prevented from opening too far to damage the body by a round-headed iron pin, which shuts against another with an india-rubber head. These pins are placed very close together, causing a great leverage on the hinges, which in time will cause them to work loose. The doors are secured by locks and Spanish latches; the latches are placed very close to the bottom of the door, so that it is impossible for the passengers to open them inside without the assistance of the guard. The commode handles are made of brass, running along the elbow rails and 18 in. down the standing pillar, so that the guard can hold by them and walk along the side of the train, to examine the tickets while the train is in motion. There is a zinc gutter fixed to the cornice of the body, to receive the water, carried off by means of a spout which runs down the end of the body. The body overhangs the carriage sides 6 in., the ends 1¼ in., and stands 1 in. above the carriage, supported by four iron brackets, which are riveted to the side of the carriage. The sides of the carriage are made of iron, this shape I, measuring 9 in. by 3 in.; thickness of iron, $\frac{5}{8}$ in. The head stocks and bars are made of oak: head stocks, 9 in. by 4 in.; middle bars, 9 in. by 4 in.; longitudinals, 9 in. by 3 in.; diagonals, 9 in. by 3 in. There is a kind of an elliptic spring in the centre of the carriage, to which each draw bar is attached; also six stepboard irons each side, three of which carry treads as well as the stepboards; the stepboards are carried past the end of the carriage 1 ft. 2 in., and are 11 in. by 2 in. The treads are made of sheet-iron well jagged; the head stocks have cast-iron end caps of a neat pattern. The guards are riveted to the bottom edge of the carriage side; the scroll irons are put on in the same way; the bearing springs contain eight plates, 3 in. by $\frac{1}{4}$ in. The draw-bar hooks and couplings are cleanly forged, and the couplings are well screwed. The side chain contains five links, the one nearest the hook being a round one, the other being the usual shape. The buffer castings stand out 1 ft. 2 in. from the head stock; the buffer rods measuring 2$\frac{3}{8}$ in. in diameter; the springs for the buffers are in the castings.

The inside of the carriage is fitted up with great taste, and of very good materials. There is a passage through the centre of the carriage from one end to the other. The roof does not show any "hoop sticks;" it is covered with drab cloth, and moulded round the sides and ends by a 9-in. moulding of walnut. It is divided into panels by 1-in. mouldings. The sides and ends are padded and closely studded within 8 in. of the roof. The seats face each other, and are supported by turned legs. There are

two cushions to each seat, the under ones being framed, so that they will draw out and meet each other to form a mattress; the cushions may be drawn together. The backs, which are divided in the centre and hinged, are let down to form a pillow, and when complete make a very comfortable bed. The elbows are of an oval shape and hinged, and are padded top and bottom. There are antimacassars to prevent the trimming being soiled by the head; as they get dirty, they are changed for fresh ones, which gives to the carriage a fresh and pretty appearance. It is provided with nets and rods; the rods are made of iron, and are gilt. There is a silver-plated match-box with matches provided for each person. The glass frames in the doors are made to lift up and down. There are some pieces of walnut framing round the lights, which are worked with springs, and as the light is lifted up it will hold it in any desired position, which prevents all jarring, keeps out all draught, and gives to the door a finished appearance. The doors are provided with blue silk blinds, which are worked by means of a spring roller. The carriage is supplied with hot and cold water, which the passengers turn on at their pleasure. There is a van attached to the train with apparatus for heating the water while on the journey: the water is conveyed by means of pipes to each coach. It is also supplied with a lavatory. The walnut used in the interior is most beautifully figured, the trimmings are very tasty, and the workmanship good throughout.

There is also a covered goods waggon, with sliding doors which run on rollers, exhibited by Austria. The framework is of oak, the "sheeting" of pitch pine. Both the wood and ironwork are most beautifully got up. The whole of the ironwork and springs are polished, and shine like silver; it looks very well indeed, but would not do for general use, as the iron would soon get very rusty. It in other respects contains no special feature. A coal waggon got up in a like manner is also exhibited.

*Russia*

Exhibits a sleeping saloon, a third-class carriage, and one waggon. The saloon is a large and heavy looking carriage, with a platform at each end, and two doors. The body has a passage through the centre. The framework is made of oak, covered with iron panels, and has a turn-under of about 3 in., which overhangs the carriage sides 1 ft. 6 in. The body is supported by seven iron brackets riveted to the carriage sides. The carriage sides are made of iron. The head stocks, bars, tables, and longitudinals are made of oak. The wheels are made of iron; buffer rods with solid heads, the rod measuring 2½ in. The body is painted lake colour, mouldings black, picked out with vermilion. The carriage or under-frame is painted black, with not a single line to relieve it.

The carriage is divided into three sections: sitting room, sleeping compartment, and lavatory—the lavatory in the centre. The coach is heated by means of a stove. The sitting room is fitted up with two chairs, couches, and seats, with a small table in the centre; couches and seats trimmed with scarlet plush edged with silver and scarlet lace of a pretty design; the table is covered with a blue cloth, and moulded round the edge. The trimming of the compartment is very tasty, and the material used of very good quality; the floor covered with a carpet to match the trimming; the roof covered with painted canvas of a neat pattern, divided into panels. The doors which divide the different compartments are veneered with walnut, and slide on rollers. The compartment also contains two cupboards and a mirror, and at night is lighted up by four lamps, each having two burners. The net rods are made of iron, and gilt. There are two glass frames to each door, one of which is balanced by weights. There is no ventilation whatever when the lights are up. The sleeping compartment is divided into four sections, with a passage through the centre. It contains sleeping accommodation for ten persons. The beds are placed one above the other; these are hinged and supported by straps. The upper beds are reached by means of a pair of small steps. The beds have no pillows for the head. There is a small shelf, supported by hinged brackets, for the use of the occupants. In other respects it is fitted up similar to the other compartment before mentioned. The third class and waggon have no special feature to recommend them.

*America*

Exhibits an American tramway car, manufactured by J. Stephenson and Co. (under Young's patent), New York. This is a very compact-looking car, and does not differ very much from those that were built at the Metropolitan Railway Carriage Works for Dublin. The American car does not carry outside passengers, whereas those built for Dublin do. Length of the body, 16 ft.; of platform, 3 ft. 6 in.; width of body at light rail, 7 ft. 7¼ in.; width at waste rail, 7 ft. 2½ in.; at bottom, 6 ft. 1 in. There is a platform at each end and a door, eight lights each side of the car, with neat landscapes painted above them edged with gilt mouldings. There are two movable lights at the end of the car, protected by three bars. The seats run down each side of the car, supported by four turned legs 1¼ in. in diameter, which are boarded and covered by movable cushions of green plush; the backs of the seats are trimmed with the same material. There is a caboose in the centre of the roof 7 ft. 9 in. long by 3 ft. 10 in. wide. The roof is supported by 18 hoop sticks made of ash and framed 9 in. apart, with two stronger to support the caboose. The roof contains a great amount of work occasioned by the caboose. The side lights and blinds—the blinds made of pine—lift up and down; when up are secured by springs, very awkward for the passengers to adjust, who must frequently get their fingers pinched. An iron rod runs along each side of the caboose to strengthen the roof; leather straps are attached to it for the accommodation of the passengers to hold by when getting in and out; and a mirror and paraffin lamp at each end of the body. The lamp is a patent one, by F. B. De Keravenen (patent assigned to J. H. Bailey and G. A. Jones). The lamp works by means of clockwork, working a small fan, which supplies air so that the lamp will burn without the aid of a glass chimney. The floor of the car is neatly carpeted. The strongest part of the framing is made of oak; the pole is made so that it will fit each end of the car. The brake handles, commode, and all the other furniture is silver plated. The wheels are Raddin's Elastic Car Wheels (Lynn, Massachusetts); the brake is worked by means of cross levers. The middle panels are painted yellow; the top and bottom panels white fine lined to match; in the centre panel there is a painting of Grace Darling. The workmanship is good throughout, with the exception of the painting, in which there is plenty of room for improvement.

### Round Brake.

The round brake system (Schouberszky), stops a train in ten seconds, not only with the aid of engine-driver, brakesman, or any passenger, but also by a self-acting power in case of rupture or other injury to the train.

This contrivance for quickly stopping the train presents a marked contrast, by its outward appearance, to the brake at present in use—the blocks of metal or wood pressed against the wheels in ordinary use being replaced by a disc, which simplifies the whole to such a degree that the management of the brake demands only a very slight exertion. The disc approaching the wheel is caught by it, and the motion of the train causes the pressure to be exerted on the disc, and immediately arrests the train. For the quick operation of such brakes (distributed along the train), a very watchful agent is required; such an agent is found in compressed air. Air, so liberally diffused on the earth, possesses the property, if subjected to compression (in a reservoir) to a degree twice that in which it is in a free state, if permitted to escape through a pipe, in its desire to establish an equilibrium, will accomplish the task assigned to it with the astonishing rapidity of 1,000 feet in a second, corresponding to 750 miles in an hour. With the aid of so active an agent there is no loss of time in applying the brake. The air is conducted to each carriage by means of slender tubes, similar to those used for pneumatic bells. The pressure of air keeps by its arrangements the round brake a certain distance from the wheels, but as soon as the compressed air is applied, the operation of stopping the train is at once accomplished.

The compound action of the entire series of round brakes exert so powerful a friction, that the speed of the train rapidly lessens. The stopping is effected imperceptibly to the passenger, who feels no jolt or shock, because the resistance employed to arrest the train, acts gradually, and is not in the least accompanied by a jolt. The pipes are laid throughout and alongside the carriages. They are furnished with cocks placed, not only on the locomotive, but on each carriage, within the reach of the brakesman and passengers. By this brake anyone who observes the possibility of a collision is able to stop the train, simply opening the cock, to let free the compressed air. This facility of quickly stopping the train will, there is no doubt, prevent many accidents, the anticipation of which at present causes so much alarm to all railway passengers. They will have a far greater sense of security when they know the destructive speed of the train can be so quickly and easily stopped by a brake so effectual as the "round brake" of Schouberszky. It possesses every quality for ensuring safety, which has been proved by repeated trials in Russia. Experiments, made outside the Machine Hall of the Exhibition, gave general satisfaction, and appeared to prove its efficiency.

(*To be continued.*)

XUM